Study on the possibility to set up a carbon border adjustment mechanism on selected sectors

Final report

Contract number: TAXUD/2020/AO-14

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STUDY ON THE POSSIBILITY TO SET UP A CARBON BORDER ADJUSTMENT MECHANISM ON SELECTED SECTORS

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Executive Summary

The European Union has committed to become the first climate-neutral continent by 2050[1]. To make this a reality, all parts of the economy will have to reduce their emissions. The industrial sector in particular will undergo a major transformation. Clean production processes, efficient material use and enhanced recycling will be required. In its Communication on the EU Green Deal[2], the European Commission has presented a plan to make the EU's economy sustainable by turning climate and environmental challenges into opportunities, and making the transition just and inclusive for all.

The logic of intervention

Carbon pricing has a key role to play in this transformation. The EU Emissions Trading System (EU ETS), which the European Union introduced in 2005 as the world's first international emissions trading system, is a cornerstone of the EU's policy to combat climate change. It has shown that putting a price on carbon is possible[3].

The EU ETS works on the 'cap-and-trade' principle. A cap is set on the total amount of certain greenhouse gas (GHG) emissions that can be emitted by installations covered by the system. Within the cap, companies receive or buy emission allowances, which they can trade with one another as needed. The limit on the total number of allowances available ensures that they have a value.

Yet allowances are currently allocated for free to operators of installations in sectors identified at risk of carbon leakage. Free allocation partially mutes the carbon price along the value chain, reducing incentives for an efficient use of carbon-intensive materials and for substitution by lower-carbon alternatives. A limited reflection of carbon costs in material prices also undermines the business case for investments in climate-friendly material production processes.

Therefore, the EU ETS arguably needs to be complemented with additional measures. The President of the European Commission has thus committed to complementing the EU ETS with the introduction of a carbon border adjustment mechanism (CBAM), i.e. a mechanism that ensures that imported products sold to consumers face similar levels of carbon pricing in the European Union as similar domestic products. As she has constantly emphasised, such carbon border adjustment measures should be fully compliant with World Trade Organisation rules[4]. CBAM should thus support global climate and trade cooperation, and contribute to making the EU ETS a policy example others may choose to follow.

One primary objective of a CBAM is to support the reduction of GHG emission and ultimately the path to climate neutrality of the European Union by creating incentives for all industrial activities to reduce EU greenhouse gas emissions. Thereby, a CBAM or alternative measure should implement the principle of consistent carbon pricing, i.e. it should avoid both under- and overpricing of GHG emissions. In doing so, the CBAM is expected to make a significant contribution towards the achievement of the EU’s Green Deal objectives, including incentivising the investments that put Europe on an emission pathway towards climate neutrality by 2050.

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[1] Von Der Leyen, A Union that strives for more (2019), p. 5.

[2] COM/2019/640 final: The European Green Deal.

[3] See European Commission, Report on the functioning of the European carbon market, COM(2020) 740 final.

[4] See e.g. Von der Leyen, A Union that strives for more (2019), p. 5; Von der Leyen, State of the Union Address 2020.

Another primary objective of a CBAM CBAM is to ensure that the EU's increased climate targets are not undermined by the unintended consequence of an increase of emissions outside of the EU. So far, the risk of carbon leakage has been addressed through targeted free allocation and indirect cost compensation. The volume of allowances available for free allocation will, however, decline and a more stringent emission cap will likely contribute to an increase of the EU ETS carbon price. This would raise the costs incurred by European producers for carbon emissions and could create the risk that greenhouse gas emissions from carbon-intensive production are relocated to other regions rather than avoided by a shift to climate-neutral production processes, climate-friendly material use and enhanced recycling. Adequately addressing concerns about carbon leakage risks is thus essential to enhance regulatory credibility of the EU ETS and the resulting carbon price.

Complementing these objectives of a CBAM is the requirement of ensuring practical feasibility and limiting the administrative burden for all actors involved and affected by such a mechanism. Moreover, while an assessment of international legal obligations such as WTO rules are beyond the scope of this study, the following options have been designed to reflect international obligations to the best extent possible. A detailed analysis of legal feasibility and potential implications is not part of this study.

Considered options for intervention

Many different approaches have been proposed for a CBAM and there are many choices to make when it comes to their exact specifications. The study identifies and analyses six core conceivable options:

- a CBAM on imports of carbon-intensive materials at fixed reference level with full auctioning (in the report referred to as Option 1a);
- a CBAM on imports of carbon-intensive materials at the level of actual emissions with the option for importers to use the reference level with full auctioning (Option 1b);
- a CBAM on imports of carbon-intensive materials complementing free allocation (Option 2);
- a CBAM on imports and exports of carbon-intensive materials also as part of products with full auctioning (Option 3);
- an excise with a CBAM on carbon-intensive materials with continued free allocation (Option 4);
- a carbon added tax with a CBAM (Option 5).

Option 1a: CBAM on imports of carbon-intensive materials at a reference level with full auctioning would apply a CBAM to imports of certain carbon-intensive basic materials at a reference value. The CBAM would then take the form of an obligation on the part of importers of the basic materials to pay an import tax or surrender a number of allowances corresponding to a carbon intensity reference level of the basic material. In order to minimise uncertainties for the EU carbon markets in case of surrendering allowances, the obligation would relate to additional notional allowances that would be issued for this purpose at a price set by the clearance price for EU ETS allowances auctions. As alternative modes of payment the surrender of EU ETS allowances or tax payment are considered.

Such a scheme, which would coincide with a move to full auctioning of allowances, would be relatively easy to operate. However, carbon leakage risks would not be addressed in export markets, as European producers within the EU ETS would remain exposed to carbon costs that are currently not present for foreign producers. Thus, exports from the EU might decline, even if their EU ETS installations had lower emissions than foreign producers. Carbon leakage risks would also not be addressed for manufacturing of basic material products, components and final products that might result from carbon costs included in material prices for Europe manufacturers but not for imported manufactured products.

Option 1b: CBAM on imports of carbon-intensive material at the level of actual emissions with full auctioning would again apply the CBAM to imports of certain carbon-intensive basic materials, but importers would be given the opportunity to demonstrate that actual emissions were lower than the reference level. The CBAM could then consist in the obligation on the part of importers of carbon-intensive materials to surrender notional or normal EU ETS allowances or to pay an import tax. Again, the point of departure would be a carbon intensity reference level of the imported product. In contrast to the first core option, however, importers would be given the opportunity to demonstrate that actual carbon emissions for the specific imported product would be lower. The number of notional allowances to be surrendered would then correspond to the actual carbon emissions for the particular imported product rather than the reference level.

Such a scheme could also motivate foreign producers and EU importers to reduce their carbon emissions. Yet it would be more complicated to operate as it requires extraterritorial verification. Moreover, the opportunity to reduce or avoid liabilities for imports by reducing the reported emissions from the production process would create significant risks of so-called resource shuffling: foreign materials producers might attribute existing low or zero-carbon materials, biomass, scrap or electricity to production of materials that are exported to the EU and thus profit from a reduced import liability. They might also attribute carbon emissions to by-products (waste gases, heat, power), unless strict Monitoring, Reporting and Verification (MRV) rules would limit such approaches. The increased profitability might increase exports to the EU and ultimately result in an increase of production and associated emissions outside of the EU. Thus, resource shuffling would risk undermining the environmental effectiveness of the mechanism. In addition, as in Option 1a, the carbon leakage risks would not be addressed in export markets, as well as at the stage of the value chain not covered by the mechanism.

Option 2: CBAM on imports of carbon-intensive materials complementing free allocation would retain free allocation as in the current EU ETS without a CBAM (referred to as the business as usual (BAU) scenario in this report) and combine it with a CBAM on imports of carbon-intensive materials and basic material products. Again, the CBAM would be limited to imports of these basic materials and not include refunds for exports from the EU. The CBAM would be for carbon costs not addressed by free allowance allocation. Hence the reference value would be reduced by the free allocation granted to EU installations. If, for example, 80% of the defined carbon intensity level were covered by free allocation, the remaining 20% would be covered by the CBAM. Carbon leakage risks in export markets, along the value chain, and from resource shuffling would gradually increase with the declining level of free allowance allocation.

While free allowance allocation levels are high, this mechanism would during the transition period not achieve one of the primary objectives of the CBAM, namely to ensure that the EU ETS carbon prices create consistent incentives for all industrial activities that can contribute to reducing EU greenhouse gas emissions.

As the free allocation declining over time, the gradual move towards auctioning would increase carbon pricing incentives along the value chain and for clean production processes and Option 2 converges to Option 1.

Option 3: a CBAM on imports and exports of carbon-intensive materials including as part of products with full auctioning would seek to implement carbon pricing in line with the destination principle. Under that principle, excises and other indirect charges are applied to all domestic consumption (produced domestically or imported), whereas any goods or services that are produced domestically, but consumed elsewhere, would be exempt. The approach combines the coverage of imports of basic materials also as part of basic material products and selected components and final products with a corresponding relief for exports. This ensures that there would be no accumulation of the burden under the CBAM when a product crosses the border several times.

The approach would improve the consistency of carbon prices for domestically produced products sold domestically, but the refund would largely mute carbon price incentives for European actors where their products are exported. Like Option 1b, some incentives would result for foreign producers to improve the carbon intensity of products exported to the EU. With respect to export markets, carbon leakage risks would be addressed in and along the value chain. However, carbon leakage risks from resource shuffling on imports and exports would remain a concern.

Option 4: Excise or charge with a CBAM on carbon-intensive materials including as part of products and free allocation would complement the EU ETS with an excise or other charge on a defined set of carbon-intensive materials. The charge would be based on a reference value per tonne of the material, irrespective of the specific production process and location. As is the rule for excises, carbon border adjustments would be integrated into such charge: The import of carbon-intensive materials (also as part of products) would be subject to a charge at the border. Therefore, the charge would be applied to all concerned materials placed on the EU market, irrespective of whether they were produced within the EU or imported. Conversely, the liability under the charge would be waived where materials (again also as part of products) are exported. Free allocation of allowances based on the EU ETS benchmarks would continue in order to provide carbon leakage protection and would also be granted to clean production processes as in the reference scenario.

Consistent carbon price incentives would emerge from the EU ETS with free allocation for carbon efficient material production within the European Union while the excise ensures consistent incentives along the value chain. The combination of both instruments would also create credible incentives for climate-neutral production processes. The mechanism would, however, in contrast to Options 1b, 2 and 3, not create any incentives to increase carbon efficiency of material production outside of the EU. With consistent carbon price incentives and cost allocation, it would not be necessary to reduce the level of free allowance allocation. Hence, carbon leakage risks could be comprehensively addressed with the free allowance allocation. As the excise is based on fixed reference values, resource shuffling risks would be avoided.

Option 5: carbon added tax with a CBAM would create a tax payment at each production step for every tonne of CO_2 equivalent emitted in the production of the product; any tax paid under a previous production step could be deducted as an input tax. In contrast to the excise duty, a payment would become due at every production step involving carbon emissions. Where emissions are covered by the EU ETS, the costs of allowances purchased would be considered. While ultimately the final consumer would pay the carbon added tax (CAT), producers would collect it in all intermediate production steps. It would thus reflect the fact that carbon emissions occur all along the value chain. Imports of all goods would be liable for the carbon added tax at the carbon intensity reference value for the product or, where they are reported, actual emissions. The carbon added tax accumulated over the different production steps would be refunded for exports.

The approach would require tracing and attribution of carbon costs not only from production of basic materials, but also carbon costs incurred in subsequent production stages, along complex international value chains. **This option is currently considered not realistic**: it would involve a significant and potentially disproportionate administrative burden both within Europe and internationally; most importantly, it would require relevant MRV requirements which are currently not in place in the majority of jurisdictions. As it is currently not considered realistic to put the required emission monitoring and tracing systems in place, this option has been excluded from further assessment. The mechanism would largely exhibit similar attributes as Option 3 with effective incentives for emission reductions and avoidance of carbon leakage risks together with limited incentives for emissions reductions of products to be exported and carbon leakage risks from resource shuffling. It would create additional incentives for the mitigation of emissions along the value chain where these are not already in place from national carbon pricing and energy taxation schemes.

As seen above, the assessment of the options shows that the choice of the preferred option by the European Commission will have substantial implications as to whether the objectives of the carbon border adjustment mechanism (effective contribution to climate neutrality and prevention of carbon leakage) can be achieved.

Key elements for defining the scope of the CBAM

The scope of a CBAM, in terms of the basic material products to be covered, is analysed in this report. Starting from the "carbon leakage list" used for the EU ETS free allocation rules, sectors are identified that would provide a reasonable balance between administrative effort and broad coverage of GHG emissions in the EU, which might be "leaking" in case of increased carbon costs in the EU in the future. Next, practical feasibility issues are discussed, such as the need to unambiguously identify and distinguish products covered, and the importance of the ability to define reference levels for the embedded emissions of materials and products. Taking all these considerations into account, a possible scope of the CBAM is presented using several "ambition levels".

For Options 1 to 3 (the CBAM applies to imports), the lowest ambition level would mean the inclusion of specified basic materials of the sectors cement, iron and steel, aluminium, fertilisers and polymers. For polymers, however, some technical difficulties would have to be overcome to define appropriate values for the embedded emissions. The same reason applies to refinery products[5], which have therefore been not added to this first group of basic materials. As a next step (if all data requirements for determining embedded emissions can be satisfied), further products in these sectors, as well as specific products from the refinery sector and from inorganic and basic organic chemicals could be included. The third step might be to cover *all* sectors from the Carbon Leakage List (again, subject to solving the data requirement issues and not exceeding reasonable administrative burden). The last step, the inclusion of more downstream and consumer products, currently seems out of reach.

For Option 4 (excise or charge with a CBAM on carbon-intensive materials including as part of products and free allocation) the data requirements would be less stringent and therefore a broader range of basic materials could be directly included with specified values (cement clinker, steel, aluminium, fertiliser and possibly high value chemicals).

Assessment of certain aspects of the options

Implementation approaches are also discussed in great detail. They are relevant to a varying degree across the main options discussed before. First, various options to define a reference carbon price are given. Next, the ways to define "embedded emissions" of a material or product are presented as the basis on which the CBAM obligation would be calculated. A proposed definition and formula are given, in order to distinguish "embedded emissions" both from EU ETS emissions as well as from other product carbon footprint approaches. As embedded emissions would correspond to "EU ETS-like" emissions along a clearly defined,

[5] Please see footnote 68 on page 90 for a short description of the technical issues involved.

limited value chain, embedded emissions would be a very specific (i.e. narrow) cradle-to-gate type of partial product carbon footprint. It is also considered possible to take into account emissions for which a carbon price has already been paid in order to arrive at "effective embedded emissions" which would then form the basis to calculate the CBAM calculation. Starting from these definitions, the chapter further elaborates the necessary elements regarding MRV (Monitoring, Reporting and Verification) of embedded emissions for goods from third countries, based on experience in the EU ETS. These MRV rules are also linked to the way in which any default reference values for embedded emissions would be determined.

Options for the practical approach to the implementation of the CBAM are elaborated. This includes the design of an annual "compliance cycle" for options that would not rely on mostly automatic processing of customs data. This would be necessary for the options where the importer of goods wants to demonstrate the level of actual embedded emissions of the imported good instead of using default reference values. Thereafter follows an outline of how the different "payment modalities" for main Options 1 to 3 can be implemented, i.e. as a tax on imports, or by surrendering either notional or normal EU ETS allowances. For the case of notional allowances, some thoughts are given as to how they would be generated, transferred or surrendered in practice, with the conclusion that they should be non-tradable and based on the price of actual EU allowances (EUAs). Another section of Chapter 6 assesses the coherence of a CBAM with the EU ETS, and its potential impact on the EU ETS. For this purpose, some options are discussed on how to adjust the EU ETS cap, should it be required because of the use of normal EU ETS allowances for CBAM compliance.

Additional questions relating to the excise are presented in a separate section (Section 6.6), given its distinct nature. Given that the excise is not intended as a fundamental alternative to an emissions trading system, it follows that the design of the excise should be such that it ensures complementarity with the EU ETS. At the same time, the design can rely on the age-old experience with excises in general and the legal framework created by the EU Excise Directive in particular. Against this background, the excise should be calculated as the embedded emissions multiplied by the yearly average carbon price. The excise should, in line with standard excise practice, contain a duty suspension mechanism so that the excise would be due only once the product has been released for consumption. The excise should have an external interface in the form of a carbon border adjustment mechanism. This would make sure that carbon-intensive materials covered by the excise that are consumed in the European Union would be subject to the same carbon pricing through the excise as domestically produced materials. The excise would thus be implemented in accordance with the destination principle. Regarding the legal form, there are three potential technical approaches for implementing the excise. It may either take the form of a new tax to be levied by the European Union or a harmonised tax to be levied by Member States or finally of a consumption charge that would be accessory to the EU ETS.

With respect to acknowledging the climate policies of trading partners, the CBAM should close the relative gap between the actual carbon constraints imposed in the home country and that of the trading partner. Thus, the level of the CBAM could differentiate between different trading partners, depending on the level of ambition of their climate policies, as they apply to emissions from the industries in question: countries with lower ambition would face a higher CBAM; those with higher ambition a reduced one. A crucial choice concerns how the relative stringency of third-party climate policies can be measured. The analysis discusses several options – a country's commitments as documented in their NDCs, their enacted climate policies relevant to industry, and the carbon price applicable to industry. Of the different options, the most feasible one is the carbon price applicable to emissions from the industries concerned. The carbon price provides a metric that is unified, relatively robust and comparable across jurisdictions. To the extent that the effective carbon price for relevant industries in other jurisdictions can be determined with a reasonable degree of accuracy, it could be used to adjust the level of the CBAM obligation for various countries. In this way, despite some conceptual and practical limitations, the carbon price applicable to industry emissions can still provide a proxy for the ambition of domestic climate ambitions, and the effective carbon constraint that emitters in the respective industries face. For this purpose, the concept of "effective embedded emissions" has been developed in this report**.**

It should be noted, though, that there are currently only few instances where an explicit carbon price applies to industry emissions. While there is a large and growing number of carbon pricing systems in the world, not all of them cover industrial GHG emissions – and those that do are predominantly sub-national systems.

In terms of blanket exemptions from a CBAM, trade with countries or jurisdictions that have a carbon market linked to the EU ETS should clearly be exempted from a CBAM. A further option concerns Least Developed Countries (LDCs). Yet, while preferential treatment for LDCs is an established procedure in other areas of trade policy, it raises questions in the case of a CBAM, above all since there are other, more targeted channels to support LDCs in developing industrial production structures that are compatible with long-term climate goals.

The assessment of compliance costs for businesses shows that using default values for the quantification of embedded emissions results in significantly lower compliance costs than basing the calculations (partly) on actual, monitored and verified emissions. In comparison between the option of an import tax and a system of surrendering notional EU ETS allowances, the import charge creates marginally lower compliance costs if the import charge is only applied to basic materials. This is because of the easier integration in existing obligations. An excise-based system creates relatively low costs per economic operator. However, because of the higher number of participants including also EU producers and businesses using the covered basic materials as an input, the estimate of total compliance costs is higher.

The assessment of enforcement costs for authorities gives similar relative results. Costs arise from processing additional data points and controls of the compliance of businesses. The processing of claimed actual emissions is the biggest cause of differing enforcement costs. Therefore, using default values for embedded emissions of materials results in lower enforcement costs than if actual emissions are used. As for compliance costs, the surrender of notional EU ETS allowances would result in higher enforcement costs than an import tax, because new processes for imports need to be established and enforced. In an excise-based system, authorities face similar costs as for comparable existing excises. The total largely depends on the number of economic operators for which the excise applies.

Border adjustments for electricity

Electricity is discussed separately in this report due to its distinct physical characteristics: because it is a homogenous product, electricity imported into the EU cannot be unambiguously traced back to a specific generator. Also, the EU is connected to its neighbours via interconnectors, which are subject to capacity constraints. Determining the carbon content of imported electricity and calculating the CBAM rate therefore has to follow a different approach than a CBAM on carbon-intensive materials.

Four design options for a CBAM on electricity imports are considered in this study: transaction-based approaches that set the border adjustment on the emission intensity of individual transactions; marginal emissions-based approaches that set the carbon border adjustment on the marginal emission intensity of the exporting system; average-emissions based approaches set the carbon border adjustment on the average emission intensity of the exporting system; and an option that is not technically a CBAM, but relies on joint cross-border renewable auctions to achieve the same objectives. This study does not consider any options that refund carbon costs for electricity exports.

So far, there has been little practical experience with, or research on, the application of a CBAM to electricity. The transaction-based CBAM applied to electricity imports in California offers limited insights for an EU CBAM on electricity imports due to fundamental differences in how electricity is transacted in each market. It does, however, highlight the risk of resource shuffling when relying on the carbon intensity of the individual electricity generator. In the EU electricity market, which is characterised by high shares of short-term transactions (day-ahead, intraday and real-time markets), a transaction-based approach is not practical. Marginal and average emissions-based approaches circumvent the need for transaction-specific data and avoid resource shuffling by relying on system characteristics, with different options for temporal granularity and locational specificity. Of these approaches, marginal emissions-based options better reflect the carbon intensity of generation capacity dispatched to serve exports to the EU. Joint renewable auctions, finally, deploy a different approach that relies on cross-border cooperation in tenders for renewable energy projects, coupled with allocation of physical transmission rights.

1. INTRODUCTION

Overview of the project

The European Green Deal adopted by the European Commission[6] represents the next step in EU climate policies with the goal of tackling climate change and pioneering the international response to counter increasing carbon emissions. The centrepiece is the objective of a carbon neutral European Union by 2050 with increasingly ambitious objectives for intermediate steps like a 55% greenhouse gas emissions reduction target for 2030.

A carbon border adjustment mechanism (CBAM) in the EU can be one instrument of the policy package helping to achieve these objectives by applying a carbon price not only to goods produced within the EU but also to those imported from other places of production.

This study supports the inception of a CBAM by providing feasibility assessments of the existing design options against a set of criteria and providing support on the selection of sectors to be covered by such a mechanism.

As a first step, however, this report develops the logic of intervention comprising the problem and drivers creating the need for a CBAM, the objectives of the mechanism and the rationale of EU intervention. Following this, the report presents a set of design options and the criteria for their assessment. Third, the considerations for the decisions on the potential scope of the mechanism are presented. Finally, several issues of practical implementation, such as the necessary MRV system, a potential institutional setup and the impact of a CBAM on the EU ETS are discussed, and the administrative costs of such a system are estimated.

Introduction to the report

This report presents the completed results of the project. First, the logic of intervention will be presented in Chapter 2. Second, the main conceivable design options for a CBAM are elaborated in detail in Chapter 3 and assessed against two primary objectives, two secondary objectives and two requirements. Third, considerations on the selection of the scope for a CBAM with a view of the materials and products to be included are presented in Chapter 4. Chapter 5 sets out in detail sub-options for the practical implementation of the CBAM regarding design elements such as the reference carbon price, the definition of embedded emissions used to calculate the CBAM obligation for imported goods and the necessary MRV[7] system. That chapter also discusses the impact of the CBAM on the EU ETS and potential administrative costs. A separate Chapter 6 is dedicated to the possibilities to include the power sector (electricity production) in the CBAM.

2. THE LOGIC OF INTERVENTION

This section describes the logic a carbon border adjustment mechanism has to follow as a policy intervention. First, the underlying problems are described that create the need for policy action. As a second step, the objectives of the intervention are presented. The third step formulates the rationale of the EU intervention as a result of the problems and objectives.

[6] COM(2019) 640 final: The European Green Deal.

[7] Monitoring, Reporting and Verification.

2.1. Problem definition

Carbon pricing in the context of increasing EU climate ambitions

The global climate is changing as an effect of the increasing emission of greenhouse gases (GHG). In particular, carbon dioxide emissions (referred to as carbon) from human activities contribute about 80% to the warming of the atmosphere together with other greenhouse gases such as methane or nitrous oxide[8]. Figure 2-1 illustrates increasing global anthropogenic CO_2 emissions since 1970.

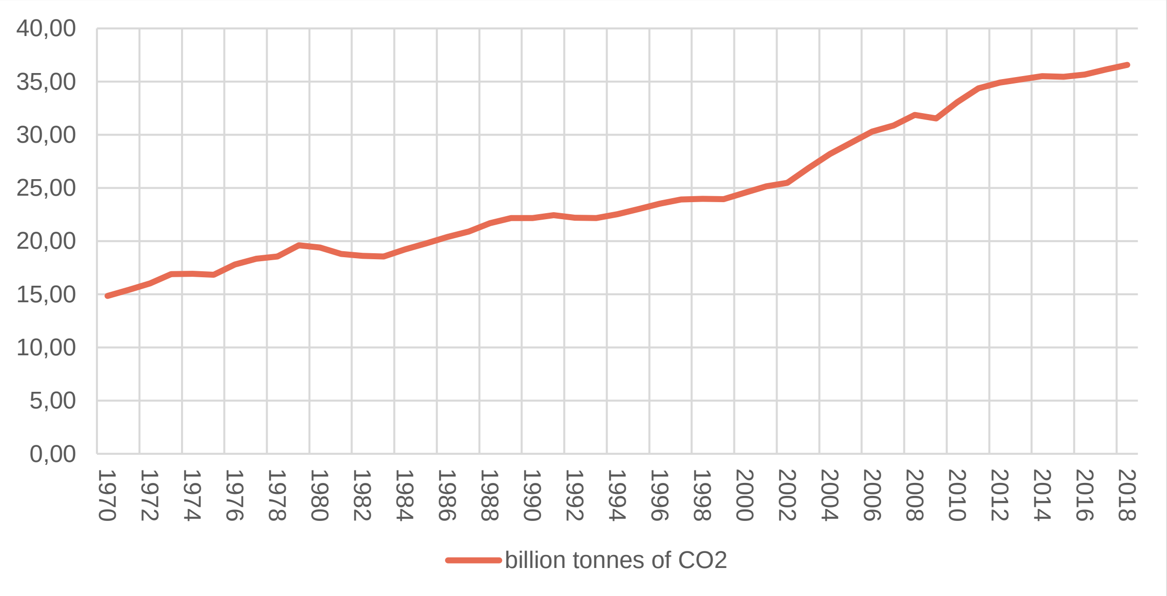

Figure 2-1: Development of global anthropogenic CO_2 emissions. Own illustration. Source: ourworldindata.org.

The European Union is increasing its climate ambitions consistently with the goal of reaching climate neutrality by 2050[9] as part of its commitment to the Paris Agreement. This is the key climate target set by the European Green Deal. In the process of achieving this target, intermediate goals for 2030 are being revised to reflect the increased ambition. Higher emissions reduction targets of 55% instead of 40% reduction in 2030 require revisions of existing climate policy instruments to achieve the new objectives.

In order to achieve the climate targets, the EU considers pricing of carbon emissions as an important instrument of the policy package to support the transformation of industries towards climate neutrality. Since 2005, direct carbon emissions of industrial sectors and emissions from electricity generation are priced in the EU Emissions Trading System (EU ETS). With this system, the EU has established a carbon price as part of its commitment to reduce GHG emissions. However, the international tradability of goods exposes EU production to competing products that are not subject to a carbon price. The increasingly ambitious GHG emissions reduction targets will likely require lower volumes of emission allowances and

[8] Other GHGs are usually quantified in CO_2 equivalent. Even though the relevant emissions are wider, the term carbon emissions (short for carbon dioxide) refers to all GHGs covered by the EU pricing mechanism.

[9] COM(2019) 640 final: The European Green Deal.

therefore higher prices in the EU ETS, which creates an even larger difference to countries without carbon pricing mechanisms.

Differences in the price charged for GHG emissions and thus production costs create a risk of carbon leakage. This term is understood as an increase in greenhouse gas emissions in third countries where industry would not be subject to comparable costs induced by carbon pricing. With the aforementioned increase in ambition, which will likely translate into an increased EU ETS price in the EU, the risk of carbon leakage is amplified the larger the difference becomes.

The EU ETS currently addresses this risk by granting free allowances and compensation for indirect carbon costs to producers in sectors at risk of carbon leakage. However, as a result of the measures to mitigate the risk of carbon leakage, the impact of the carbon price to foster innovation in low-carbon technology and resource efficiency is weakened and not consistent across products. This is because the effective share of priced emissions differs, as free allocation distorts the CO_2 price signal of EU ETS.

The EU's carbon pricing policies need to provide fully effective incentives for efficient and climate-neutral production processes, efficient use and choice of materials as well as for recycling to effectively achieve climate neutrality in the EU in the context of the global emissions reductions set out in the Paris Agreement[10].

As an EU instrument, the EU ETS carbon price only applies to production sites within the borders of the EU and only to direct GHG emissions. GHG emissions of imported materials are not priced at a comparable level. Substantial international differences in carbon pricing levels could induce the relocation of production instead of reducing emissions from industrial production that is faced with global competition from countries with no or very low carbon prices. Current carbon price levels may not be high enough to induce such relocations. Furthermore, free allowances further reduce the impact of the EU ETS price on trade-exposed industries.

However, the clearly increasing ambition in the EU to reduce GHG emissions faster will result in larger carbon price differences between jurisdictions. This will increase the risk of carbon leakage where trade partners do not take similar steps. As a result, the environmental effectiveness of EU climate policies may be frustrated by increasing GHG emissions in third countries. The ultimate outcome could then be no or even a negative effect on global emissions.

The competitiveness of EU domestic industries is reduced by higher production costs compared to international producers due to the EU ETS. The resulting potential relocation of production and of related emissions are what creates the direct, production-related leakage[11] (Droege et al., 2009; Cosbey et al., 2019). A study by Evans et al. (2020) further distinguishes the issue of competitiveness in (1) the short-run effects of competition on production decisions depending on the relatively short-term marginal costs of production and (2) the long-run effects on capital and investment decisions that are based on the long-run marginal costs influenced by the cost of capital. The latter, also referred to as

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[10] Carbon pricing is one of many different instruments that aim at reducing GHG emissions and achieving climate neutrality. However, the focus is on carbon pricing as it forms the basis of climate policies and varies only slightly between Member States. It also results in direct price differences between production at different origins, creating the need to prevent the risk of carbon leakage.

[11] Other channels for the leakage of carbon that are described in the literature are (1) the energy market channel, which is caused by changed demand for fossil fuel as a result of reduced fossil energy consumption as an effect of carbon pricing in the country with the carbon price; (2) the spill-over channel, which captures the spreading of low-carbon policies and technology potentially resulting in "negative leakage"; and (3) the income channel, which considers changing consumption patterns because of altered global income distribution caused by the carbon price. See also Cosbey et al. (2019).

investment leakage, occurs as a result of unstable or unfavourable long-term expectations to production costs, including carbon prices. This can lead to investments being made in production capacity in third countries rather than in the EU with long-term effects on the global production landscape (Evans et al. (2020).

Carbon leakage risks through relocation of production are also addressed in existing carbon pricing mechanisms outside the EU. The instrument of free allowance allocation is used in all major jurisdictions with emission trading systems in place. Besides the EU ETS, the schemes in California, Quebec, New Zealand and the Republic of Korea allocate parts of their allowances for free (varying methods and shares between 21% and 97%) (Acworth et al., 2020). The same applies to the ETS pilots in China, which also allocate allowances to the covered power plants for free (IEA, 2020).

The combination of competition in global supply chains and the provision of free allowances results in a reduced and uncertain carbon price incentive for climate-neutral production processes[12] and for the efficient use and choice of materials in manufacturing and recycling. The aforementioned points result in a situation, where carbon emissions embedded in goods placed on the European market are not priced consistently depending on the material and its origin, thus limiting the incentives to reduce emissions.

Without the support of carbon pricing incentives, it will be difficult to materialise the GHG mitigation potential of material production in Europe. Meeting the (increased) 2030 emissions reduction target and 2050 climate neutrality objective for Europe would be put at risk. On the other hand, carbon leakage creates the risk of achieving the EU carbon emission reduction targets for 2030 and 2050 only at the expense of also achieving the international climate objectives.

Evidence on the existence of carbon leakage

While the difference in or the complete absence of carbon prices across regions is clearly documented[13], the existence of carbon leakage is assessed in different ways and discussed as results diverge to some extent.

A number of studies have been carried out as *ex-ante* analyses using simulation models. These often find a substantial risk of carbon leakage in the absence of carbon leakage protection mechanisms such as free allocation**.** Böhringer et al. (2018) present the estimation of carbon leakage in Computational General Equilibrium (CGE) models at an average of 10% to 30%. The percentage indicates the share of saved domestic emissions that are offset by increased emissions in other parts of the world. In a similar way, Branger and Quirion (2013) perform a meta-analysis of CGE studies and find a typical range of carbon leakage estimates between 5% and 25% with a mean at 14% without any adjusting policy. In these models, prices are a central factor in the quantification of carbon leakage as the simulations focus on the determination of price-elastic market supply and demand (Böhringer et al., 2018). In other studies, partial equilibrium models are applied to specific industries. These studies tend to focus on emission-intensive and trade-exposed (EITE) sectors and find higher leakage rates for these sectors in particular (e.g. Demailly and Quirion, 2006 for the cement industry). Some studies (Böhringer et al., 2012; Weitzel & Peterson, 2011) find a preventive effect of border

[12] By "climate neutral production processes" we mean new processes that are very low-carbon or zero-carbon and as such needed for a transformation of the economy towards climate neutrality, e.g. direct reduction of iron ore to iron using renewable ('green') hydrogen or cement production coupled with CCS.

[13] See for example the map of the Institute for Climate Economics' indicating the existence and price level of carbon pricing policies (https://www.i4ce.org/download/global-carbon-account-in-2020/).

adjustments for direct, production-related leakage, but indicate that leakage created by lower energy prices outside of the geographical scope of the mechanism cannot be prevented by such unilateral measures.

Ex-post studies quantify the existence of carbon leakage based on trade flows and embedded carbon emissions. Many of these types of studies do not find substantial levels of carbon leakage from existing mechanisms like the EU ETS. Branger et al. (2016) did not find evidence for effects on trade in EITE sectors caused by the EU ETS. Similarly, Naegele and Zaklan (2019) conclude that carbon leakage has not occurred, based on input-output data and administrative data of the EU ETS. In a review study, Dechezleprêtre and Sato (2017) conclude the same, but also explain that in existing mechanisms the cost of the environmental legislation has been relatively low in comparison to overall trade volume and value. If other costs like tariffs and transportation outweigh the carbon price, relocation of production is not attractive (Naegele and Zaklan, 2019). A World Bank report (Ellis et al., 2019) similarly concludes that carbon leakage cannot empirically be observed in trade so far.

The differences in results between the types of studies indicate that carbon leakage protection measures have been successful to date, while higher carbon prices and declining free allocation can result in an increased leakage risk and thus alter the results. These considerations align the results of *ex-ante* and ex-post studies by explaining the differences. *Ex-ante* studies often assume the absence of carbon leakage protection mechanisms. However, policy makers have always accompanied carbon pricing mechanisms with special provisions, such as free allowance allocation or carbon tax exemptions, to avoid the risk of carbon leakage. In ex-post studies of existing carbon pricing mechanisms, these leakage protection measures are therefore included.

Additionally, analytic and empirical evidence shows that as a result of the existing leakage protection mechanisms, the carbon price signal has been significantly reduced and is highly uncertain for most of the mitigation options required to achieve carbon neutrality (Neuhoff and Ritz 2019). The risk of carbon leakage in the fourth trading phase of the EU ETS is also currently under assessment in a study commissioned by DG CLIMA.

2.2. Objectives of intervention

Considering the problems described above, a carbon border adjustment aims to address the challenges of global climate change. The mechanism has the objective of supporting the reduction of GHG emission and ultimately the path to climate neutrality of the European Union. This takes place in a context where climate policies comparable in type and level to the ones in the EU are not yet undertaken by third countries. Therefore, the CBAM's subsidiary objective is to prevent the risk of carbon leakage as a result of increasing carbon prices in the EU. The European Green Deal presents these considerations side by side in its commitment to "*Increasing the EU's climate ambition for 2030 and 2050*"[14], underlining the interconnection between pursuing the goal of carbon neutrality and the protection against possible carbon leakage.

In line with the Green Deal, preventing the risk of carbon leakage under increased EU ambition ensures that the climate policies, in particular the carbon price of the EU ETS, can be fully consistent. The CBAM helps achieve the targeted reductions of GHG emissions in the EU without resulting in an increase of emissions abroad, which would undermine climate mitigation efforts, by increasing the effectiveness of price signals in the EU.

[14] COM(2019) 640 final: The European Green Deal, Section 2.1.1.

The allocation of free emission allowances aims at reducing the risk of carbon leakage by diminishing the overall carbon price on domestic producers. Conversely, a CBAM enables raising the level of ambition in line with the EU targets for 2030 and 2050 and the EU's international commitments.

The CBAM aims to establish consistent carbon pricing in the EU to provide a stable and secure policy framework for investments in low- or zero-carbon technologies. **In this way it contributes to the general objectives of enabling effective climate policies and preventing the risk of carbon leakage.** Carbon prices that differ based on the product (through free allocation) and based on origin (imports that are not covered) will be aligned to create the mentioned incentives for European and international producers alike. By applying the EU carbon price to imports, relocating production to third countries does not create a cost advantage on the EU market. Thus, investments in low-carbon production are incentivised and the effectiveness in global emission reduction enhanced, thereby supporting international climate action.

As a co-benefit, the mechanism also contributes to balancing the external costs of carbon emissions for the benefit of public budgets by internalising them. A CBAM permits the use of the internalised costs for carbon emissions embedded in products to serve the public in further reducing GHG emissions. The revenue generated in this way can be used to further support the achievement of climate neutrality in the EU and globally.

The effective carbon price reflects the polluter pays principle[15] and supports the reduction of carbon emissions from industry through the internalisation of external costs from carbon emissions that is achieved by the carbon price. The incentives created in the EU market can also apply to producers in all other countries either when they want to export to the EU or by using CBAM revenue to incentivise low-carbon production. Therefore, it supports the increase in ambition both on a political and industrial level.

Throughout all these objectives, a CBAM also requires an efficient system in quantifying carbon emissions embedded in products. This must be kept at a reasonable level of administrative burden. Therefore, an objective of the mechanism is to limit the administrative burden for industries and authorities by establishing clear and enforceable rules that effectively support the main objective of reducing GHG emissions on the path to climate neutrality.

Figure 2-2 below visualises the logic of intervention of the carbon border adjustment mechanism with the problems it addresses together with their underlying drivers and the objectives it sets out to achieve.

2.3. Rationale of EU intervention

Reducing GHG emissions is fundamentally a cross-border issue that requires effective action with the widest possible scope. The EU as a supranational organisation that represents almost an entire continent is well-placed to establish effective climate policy as it has done with the EU ETS.

Legislative action on environmental objectives is included in the competencies of the European Union in Article 192 TFEU. The achievement of the EU and international climate targets, including decarbonisation by 2050, follows the protection of the environment and therefore enables action by the EU.

[15] Laid down in Article 191 (2) Treaty of the Functioning of the European Union.

The existence of carbon pricing at the EU level for domestic production is already in place through instruments like the EU ETS (Directive 2003/87/EC) as well as national energy and carbon taxes in Member States. Based on these instruments, it needs to be ensured that carbon pricing is effective in incentivising the reduction of GHG emissions from industrial production and energy generation in the EU, while also preventing the risk of carbon leakage.

Effective carbon pricing and protection against the risk of carbon leakage in the EU single market can be established most adequately at the EU level – as long as similar international mechanisms do not exist. The interconnections in the EU single market mean that carbon leakage protection can also only be achieved effectively at EU level.

Similarly, the environmental effect on global climate emissions will be most effective, if the EU as an influential trade partner establishes consistent EU-wide rules for carbon pricing as potential example to follow, as it has done with the EU ETS. Additionally, the need for limited administrative costs is best achieved by establishing consistent rules for the entire single market, further underlining the added value of an intervention on the EU level.

Thus, the objective of achieving carbon neutrality by 2050 and the 2030 target requires – without equally ambitious global policies – action by the European Union to provide the financial incentives to reduce carbon emissions related to production, use and recycling of materials.

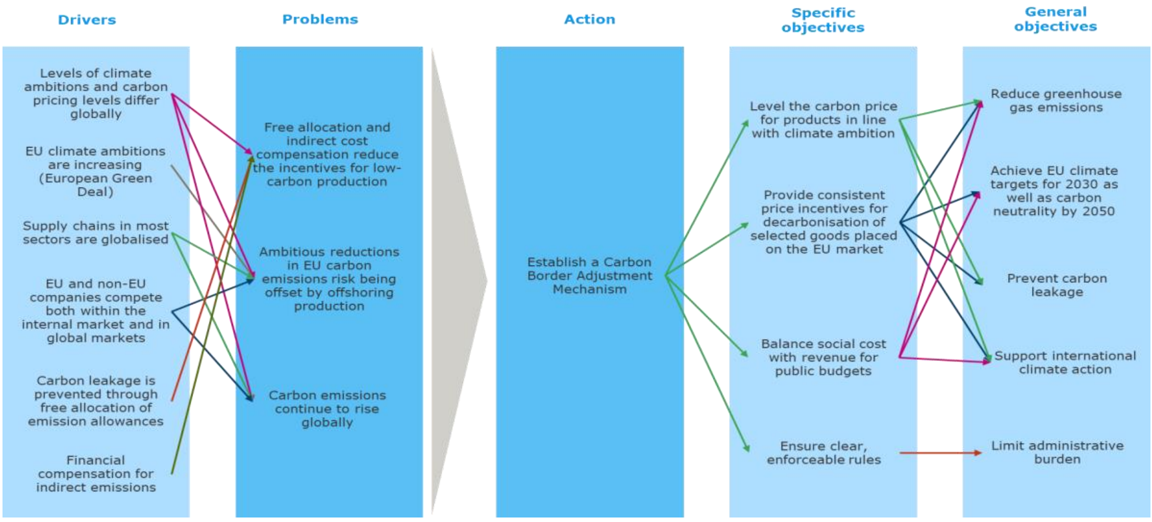

Figure 2-2: Logic of intervention for a Carbon Border Adjustment Mechanism

3. CONCEIVABLE OPTIONS FOR INTERVENTION

A diversity of measures could theoretically be used to complement the EU ETS through a CBAM or alternative measure, each of them with several possible sub-options. For the sake of clarity, the possible measures are grouped into a limited number of options. After the specification of these options, we evaluate them against a set of assessment criteria.

In Section 3.1, we provide some key definitions used in the remainder of the study. In Section 3.2, we describe a comprehensive set of options for intervention. These options are assessed in Section 3.4 against the objectives and indicators developed in Section 3.3. Conclusions from this assessment are drawn in Section 3.5.

3.1. Definitions

Carbon leakage: We use the definition introduced by Directive 2009/29/EC (recital 24): Carbon leakage is any "increase in greenhouse gas emissions in third countries where industry would not be subject to comparable carbon constraints", due to "certain energy-intensive sectors and subsectors in the Community which are subject to international competition [being] at an economic disadvantage." This means that any relocation of emissions, (partially) neutralising the effect of emissions reduction in one region through increases in emissions in other regions, qualifies as carbon leakage. This definition of carbon leakage focuses on the competitiveness channel of carbon leakage, which is addressed by the CBAM (Cosbey et al. 2019)[16].

CBAM obligation: The amount to be "paid" for a material or good under the rules of the CBAM. Depending on the payment modality chosen in the CBAM's design, this can be an amount of allowances to be surrendered (calculated as tonnes of material times the specific embedded emissions of the material), or an amount of tax to be paid calculated as the reference carbon price times tonnes of material times the specific embedded emissions.

Climate-neutral production processes: As opposed to conventional production processes, climate-neutral processes are very low or zero-carbon production processes for basic materials, such as hydrogen-based steel or cement production with carbon capture and storage (CCS). These processes currently cannot compete with conventional technologies because of significantly higher investment cost (CAPEX) and operating costs (OPEX). While these costs are expected to decline with learning by doing, they will most likely remain significantly above the costs of conventional technologies.

Consistent carbon pricing: In the context of this study, consistent carbon pricing means that the embedded emissions of a material or product are reflected in its price. Parallel to the analogous principle in international tax law, this principle requires that a product is charged according to its embedded emissions exactly once. Both more than single charging and less than single charging must therefore be avoided, unless there is a sufficient justification, such as limiting otherwise disproportionate administrative or compliance costs.

Carbon price: The price to be paid for the emission to the atmosphere of one metric tonne CO_2 equivalent.

Embedded emissions: Emissions relating to a specific partial product carbon footprint of a material or product subject to the CBAM, taking into account only emissions which would also be covered by the EU ETS[17]. Several options are proposed to define embedded emissions, depending on how broad and ambitious the design of the CBAM should be, e.g. in terms of the value chains to be covered. For details see Section 5.2.1.

[16] Other definitions take into account the overall level of global emissions, which may increase or decrease due to an offshoring of emissions from the EU, i.e. look at the net effect of domestic climate policies on global emissions. Moreover, the literature identified other channels besides the competitiveness channel, namely the energy market channel (indirect leakage), the income channel, and the technology spillovers channel (Droege et al. 2009, Cosbey et al. 2019).

[17] These are emissions that take place during activities listed in Annex I of the EU ETS Directive and of greenhouse gases specified in that Annex (Directive 2003/87/EC, consolidated version can be found under https://eur-lex.europa.eu/eli/dir/2003/87/2020-01-01).

Investment leakage: We define investment leakage as a concept closely related to carbon leakage. Investment leakage happens where producers shift investment towards production capacities outside of the EU as a result of EU carbon pricing policies. Investment leakage may preclude carbon leakage, since reduced investment within the EU may lead to a shift of production capacity outside of the EU over time.

Notional allowances: Allowances similar to EUAs (European Allowances), i.e. relating to the emissions of 1 t CO_2e, and handled in a similar electronic registry system, but which cannot be used by operators of installations or aircraft operators for compliance in the EU ETS. Section 5.4.2 discusses their properties.

Resource shuffling: Resource shuffling is the allocation or attribution of less emissions-intensive materials production (including materials embedded in manufactured goods) towards markets with higher carbon costs, while the overall carbon intensity of production in the home market remains constant. Resource shuffling can either happen in non-European markets (i.e. foreign producers allocating low-carbon materials or goods to exports to the EU) or in the domestic market (i.e. EU producers exporting more emissions-intensive materials to avoid European carbon costs, see Box 1 Section 3.3.1). The goal of resource shuffling from the point of the view of the producer is thus to avoid carbon costs either in the home or the export market.

Definitions relating to the value chain:

Value chain: The value chains referring to the embedded emissions of a material or product are understood to include the upstream processes required, starting from the raw material to make the product in question (i.e. corresponding to the specific partial product carbon footprint which relates to EU ETS processes to result in the product discussed). When discussing implications of the different CBAM options in Chapter 3, longer value chains are also possibly meant, reaching further downstream.

Upstream processes: All the processes required to end up with the product or material in question.

Downstream processes: All processes in which the product or material in question can be used. Downstream processes can include manufactured products intended for the final consumer.

Raw materials: Materials which are at the beginning of any value chain and are the result of mining or quarrying, or materials such as agricultural and forestry products (i.e. biomass). We assign zero embedded emissions to raw materials.

(Basic) materials: A material is either a (technically pure) substance or a mixture of substances in a physical form that can be sold, which has been derived from raw materials in an industrial process, during which their chemical composition is modified.

Basic material products: Formed products which consist overwhelmingly of one single basic material and which are usually produced in a (sometimes energy-intensive) process closely coupled and performed in the same installation as the basic material.

Components: This term refers to products made of more than one basic material or basic material product, which require more complex manufacturing steps. A component by itself is usually not intended for end consumers.

Final products: By this term we mean every product that is made out of components and/or further basic materials/products and is ready for sales to end consumers. In contrast to the other products in the value chain, final products are not part of other final products.

MRV / MRVA system: The rules for Monitoring, Reporting and Verification of emissions, and Accreditation of verifiers. On the EU ETS side, this includes the Monitoring and Reporting Regulation (MRR[18]), the Accreditation and Verification Regulation (AVR[19]), and MRV rules for the purpose of free allocation included in the Free Allocation Rules (FAR[20]) and Allocation Change Rules Regulation (ALCR[21]). In the wider sense, the MRV system includes the assignment of competent authorities, deadlines for the "compliance cycle", definition of penalties etc.

3.2. Options for intervention

Beyond the continuation of the status quo with free allocation of allowances that declines over time, various options for a CBAM have been previously proposed in the political or scholarly discourse. The European Commission has provided a non-exhaustive list of potential measures in its Inception Impact Assessment[22], stating that such measures could include a carbon tax on selected products – both on imported and domestic products, a new carbon customs duty or tax on imports, or the extension of the EU ETS to imports. Further options have been identified in the Terms of Reference for this study. In order to map the policy space without conflating the complexity, we work with five options, with the first option coming in two sub-options, namely:

1. Options 1a and 1b: CBAM on imports of carbon-intensive materials with full auctioning;
2. Option 2: CBAM on imports of carbon-intensive materials complementing free allocation;
3. Option 3: CBAM on imports and exports of carbon-intensive materials including as part of products,
4. Option 4: Excise including a CBAM on carbon-intensive materials including as part of products and continued free allocation;
5. Option 5: Carbon added tax including a CBAM.

Table 3-1 gives an initial overview of the basic design elements of our five core options, which are described in more detail in Section 3.2. The options vary by the emissions covered, the depth of the value chain, whether carbon costs are waived or reimbursed for EU exports, whether free allocation is continued, the type of payment and whether actual emissions from production are reflected in carbon pricing. More specific design options are left for Chapter 4 (scope) and Chapter 5 (other elements of design). Specifically, Sections 5.4.1 to 5.4.4 discuss in more detail the mode of payment for options 1 to 3 (i.e. tax, surrender of ETS allowances or surrender of notional allowances). Note that this chapter structure applies to considerations of a CBAM for industrial products. Options for a CBAM for the power sector are separately discussed in Chapter6.

Table 3-1: Overview table of the options

	CBAM on imports with full auctioning (Options 1a and	CBAM on imports complementing free allocation	CBAM on imports and exports (Option 3)	Excise including CBAM and free allocation (Option	Carbon added tax including CBAM (Option 5)

[18] Commission Implementing Regulation (EU) 2018/2066, https://eur-lex.europa.eu/eli/reg_impl/2018/2066.

[19] Commission Implementing Regulation (EU) 2018/2067, http://data.europa.eu/eli/reg_impl/2018/2067.

[20] Commission Delegated Regulation (EU) 2019/331, http://data.europa.eu/eli/reg_del/2019/331.

[21] Commission Implementing Regulation (EU) 2019/1842, https://eur-lex.europa.eu/eli/reg_impl/2019/1842.

[22] European Commission Ares (2020)1350037 - 04/03/2020, p. 2.

	1b)	(Option 2)		4)	
Emissions covered	Production of basic materials (direct and indirect)	Production of basic materials (direct and indirect)	Production of basic materials (direct and indirect)	Production of basic materials (direct and indirect)	All emissions along value chain
Scope of CBAM (depth of value chain)	Only basic materials and basic material products	Only basic materials and basic material products	Basic materials also as part of manufactured products	Basic materials also as part of manufactured products	Basic materials and manufactured products
Carbon price on exports	Yes	Yes	No	No	No
Free allocation in the EU ETS	No (full auctioning)	Yes (partially retained in transition period)	No (full auctioning)	Yes	No (full auctioning)
Mode of payment	Domestic producers buy allowances, importers buy (notional) allowances or pay tax	Domestic producers buy allowances beyond free allocation, importers buy (notional) allowances or pay tax	Domestic producers buy allowances, importers buy (notional) allowances or pay tax	EU ETS coverage plus liability created upon production and import, paid when product leaves duty suspension regime	EU ETS coverage plus payment of tax for additional emissions at each production step, imports at reference value or actual emissions
Reflection of actual emissions in carbon pricing	Yes for domestic production, reference value (Option 1a) or verified emissions for imports (Option 1b)	Only partially for domestic production, reference value or verified emissions for imports	Yes for domestic production, reference value or verified emissions for imports	Yes for domestic production, reference value for imports	Yes (tracing of incurred costs within EU and abroad, importers may opt for reference values)

3.2.1. Business as usual: EU ETS with continued and declining free allocation

Direct carbon emissions of industrial sectors are priced in the EU Emission Trading System (EU ETS). The international tradability of goods exposes EU production to competition with products that are not subject to a carbon price. Differences in the price of carbon emissions and thus in production costs create a risk of carbon leakage. The current approach to mitigate the risk of carbon leakage relies on free allocation of allowances and in some cases financial measures to compensate operators of installations for costs caused by indirect emissions. For that purpose, Commission Delegated Decision (EU) 2019/708 presents the list of sectors identified as being at risk of carbon leakage in accordance with the criteria of Article 10b of the EU ETS Directive. Secondly, the respective environmental State Aid Guidelines (Commission Communication C(2020)6400) identify sectors found at risk of carbon leakage due to their indirect emissions, and to which Member States are allowed to provide compensation for indirect carbon costs. In line with the EU's climate targets, the share of allowances that is allocated for free will decline over time also for the sectors deemed at risk of carbon leakage.

3.2.2. Option 1: CBAM on imports of carbon-intensive materials with full auctioning

Option in Brief

Depth of value chain: Basic materials and basic material products are covered by the CBAM

Coverage of CBAM: Imports only (no export reimbursement)

Free allocation in the EU ETS: No (full auctioning of allowances)

Type of payment: Domestic producers buy EU ETS allowances; importers buy notional allowances, EU ETS allowances or pay a customs duty/tax

Reflection of actual emissions in carbon pricing: Yes for domestic production; importers subject to irrefutable default values (Option 1a) or may demonstrate actual carbon intensity of production (Option 1b)

The first option is a CBAM for imported carbon-intensive materials and basic material products originating from outside the EU. There is no refund for exports from the EU to third countries. Due to the absence of such an export rebate, products further down the value chain are not included: This ensures consistent carbon pricing, i.e. avoids more than single charging of the carbon content of a product that crosses the EU border multiple times during the production process in the case of integrated value chains across borders (Ismer et al. 2020). Components and finished products would thus not be covered, neither with regard to the emissions from their production, nor with regard to the fact that they contain carbon-intensive materials[23].

Under Option 1, we assume that there is a **move to full auctioning of EU ETS allowances** as explicitly proposed by the European Green Deal communication (the CBAM "*would be an alternative to the measures [in footnote: free allocation] that address the risk of carbon leakage in the EU's Emissions Trading System*"). The free allocation of allowances foreseen in the current EU ETS architecture and termed "transitional" since the EU ETS review in 2009 would thus end. The carbon leakage protection currently resulting from free allocation would then be assumed to be achieved by the CBAM.

The carbon border adjustment would seek to mirror the burden borne by the same ("like") products (irrespective of whether produced in the EU or abroad) and would therefore be linked to the EU ETS carbon price. Technically, the CBAM could take three different forms of payment for the emissions occurring during the production of imported materials[24]. This means that importers could be obliged to:

- pay a corresponding customs duty or tax, i.e. a financial burden resulting solely from the crossing of a border by the product concerned;
- surrender EU ETS allowances;
- or surrender notional allowances[25].

Depending on which specific form the import adjustment takes, importers would either be required to surrender (notional) allowances (corresponding to the embedded emissions as discussed in Section 5.2) or pay a monetary amount reflecting the embedded emissions and a

[23] As a variation (sensitivity) to this assumption, sections 5.2.1 and 5.2.2 consider that previously paid carbon costs could in principle also be accounted for in the calculation of the emissions burden upon importation. This would avoid an accumulation of carbon costs. Such a mechanism would make it possible to cover further products along the value chain in Options 1 and 2, but comes at a higher administrative cost.

[24] These four options relate to three options proposed by the European Commission in the terms of reference, namely: b. Border tax or customs duty on carbon intensive products at the level on internal tax; d. Surrender of ETS allowances upon import of carbon intensive products; e. Surrender of notional ETS allowances upon import of carbon intensive products.

[25] Alternatively, the CBAM could also come in the form of a direct payment of an amount equivalent to the cost of acquiring these allowances.

reference carbon price. These reference values could be defined using the benchmarks used for free allowance allocation and power price compensation in the EU ETS or any other reference level to be determined based on data related to the emissions per tonne of product of installations under the EU ETS or internationally). From the perspective of the importer, these different methods of payment are largely equivalent regarding the carbon costs and incentives to reduce emissions. As the different forms may have different implications regarding their impacts on EU ETS and their practical implications, we will analyse the other forms in Section 5.3.

For importers of carbon-intensive materials, the applicable reference level for embedded emissions needs to be defined. Such a level could either be set at a reference carbon intensity value independent of actual carbon emissions, or in a manner that gives importers the possibility to demonstrate actual emissions from their production processes. To analyse the implications of both of these options, Option 1 is divided into two sub-options, namely **Option 1a (CBAM for imports at fixed carbon intensity level)** and **Option 1b (CBAM for imports at the level of actual emissions)**. Both options are briefly described in the following and will be assessed in detail in Section 3.4. The technical approaches to determine the reference levels are discussed in Section 5.2.5.

3.2.2.1. Option 1a: CBAM on imports at a reference level

The obligation to surrender notional allowances could correspond to a fixed embedded emissions value of the imported material. Such a value would be irrefutable, i.e. imported materials would be priced according to an emissions reference level, irrespective of the actual production process.

3.2.2.2. Option 1b: CBAM on imports at the level of actual emissions

As an alternative, the obligation to surrender allowances could be based on a default reference level for embedded emissions, unless the importer demonstrated that the imported materials were produced with lower emissions than the default value. In effect, this means that the embedded emissions value of the imported product would no longer be irrefutable. Instead, the CBAM would apply to the lower value of either the default reference level for the carbon intensity level or demonstrated actual emissions (since importers would only report on their incurred emissions if these were lower than the default value).

3.2.3. Option 2: CBAM on imports of carbon-intensive materials complementing free allocation

Option in Brief

Depth of value chain: Basic materials and basic material products

Coverage of CBAM: Imports only (no export reimbursement)

Free allocation in the EU ETS: Yes (partially retained)

Mode of payment: Domestic producers buy EU ETS allowances needed beyond free allocation; importers buy notional allowances, EU ETS allowances or pay a customs duty/tax

Reflection of actual emissions in carbon pricing: Only partially for domestic production; importers may demonstrate actual carbon intensity of production or rely on default values

Option 2 is largely similar to Option 1. It consists of a CBAM on imports for carbon-intensive materials and basic material products. Again, the CBAM would be limited to imports of these goods. Just as under Option 1, there would be no refund for exports from EU to third countries.

As for Option 1, several "modes of payment" (surrendering of allowances or tax payment) can be applied for implementing option 2.

However, Option 2 **departs from the premise of full auctioning**. Instead, the free allocation of allowances contained in the current EU ETS as in the business as usual (BAU) scenario would be retained. Under Option 2, the carbon leakage protection would come from a combination of continued free allocation and the CBAM. In order to guarantee consistent carbon pricing, the combined carbon price effect of free allocation and the CBAM should equate a predefined reference level of embedded emissions for a given material (see Section 5.2.3). This level could, for example, correspond to the current EU ETS benchmark or the average carbon intensity of EU manufacturing. If, for example, 80% of the defined carbon intensity level were covered by free allocation, the remaining 20% would be covered by the CBAM[26]. Such consistent carbon pricing would put importers and producers on an equal footing by avoiding a situation whereby importers are charged more than domestic producers, and vice versa.

Option 2 therefore corresponds to a combination of the BAU scenario (continued and declining free allocation) with an import-only CBAM with the option for importers to demonstrate the actual carbon intensity of their products (Option 1b)[27]. It should be understood as a transition scenario: The level of the CBAM would increase over time as the level of free allocation declines, , so that eventually Option 2 converges to Option 1b.

3.2.4. Option 3: CBAM for imports and exports of carbon-intensive materials including as part of products with full auctioning

Option in Brief

Depth of value chain: Basic materials also as part of components and finished products

Coverage of CBAM: Imports and reimbursement for exports (symmetric)

Free allocation in the EU ETS: No (full auctioning of allowances)

Mode of payment: Domestic producers buy ETS allowances; importers buy notional allowances, ETS allowances or pay a customs duty/tax

Reflection of actual emissions in carbon pricing: Yes for domestic production; importers may demonstrate actual carbon intensity of production or rely on default value

The third option combines a CBAM on imports with a refund for exports, while abolishing free allowance allocation. Thereby, Option 3 would seek to implement carbon pricing in line with the destination principle. Under that principle, carbon pricing mechanisms (e.g. from excises and other indirect charges as well as emissions trading) are applied to all domestic consumption (produced domestically or imported), whereas any goods or services that are produced domestically, but consumed elsewhere would be exempt. The relief for exports would ensure that there would be no accumulation of the burden under CBAM when a product crosses the border several times.

Adjustments would therefore not necessarily be limited to specific imported carbon-intensive materials and basic material products. Instead, under Option 3 also carbon-intensive materials that are part of components and finished products could be covered by the

[26] Option 2 follows the French proposal put forward in a 2016 non-paper, which was updated in the response from the French authorities to the Commission's public consultation on the CBAM Inception Impact Assessment (Ares(2020)1350037).

[27] In theory, Option 2 could be divided in two sub-options (just as Option 1), as to whether it would be possible to demonstrate that actual emissions were lower. However, such a sub-division would not produce additional insights and would command a price in terms of clarity of exposition. Option 2 will therefore be presented as a single option of a combination of 1b with continued free allocation.

CBAM, provided that the necessary (and more complex) MRV system is established. Extending the scope along the value chain introduces a trade-off in Option 2: On the one hand, covering products further down the value chain would help avoid carbon leakage in downstream sectors (see Section 4.4.2). On the other hand, it increases inevitably administrative complexity (see Section 5.2).

For imports, the CBAM would again seek to reflect the burden for domestic products under the EU ETS with respect to the carbon-intensive materials. Importers would thus be required to surrender (notional) allowances or pay a tax, just as under Options 1 and 2 (either according to the default value or demonstrating lower actual emissions). In order to avoid granting a subsidy, exports would be refunded not in accordance with the reference level, but based on actual emissions where these are lower than the reference level, and not more than the reference level.

3.2.5. Option 4: Excise including CBAM on carbon-intensive materials including as part of products and continued free allocation

Option in Brief

Depth of value chain: Basic materials also as part of components and final products

Coverage of CBAM: Imports and waiving of liability for exports of EU producers (symmetric)

Free allocation in the EU ETS: Yes (continued)

Mode of payment: EU ETS coverage for domestic producers plus liability created upon production and import, paid when product is released for consumption[28]

Reflection of actual emissions in carbon pricing: Yes for domestic production; no for imports

The fourth option consists of a combination of the EU ETS including the free allocation of allowances and an excise or a charge on carbon-intensive materials. Under Option 4, free allocation of allowances based on the EU ETS benchmarks would continue in order to provide carbon leakage protection. Operators would need to buy allowances to cover emissions exceeding the emissions of the EU ETS benchmarks, which are set based on the average efficiency of the 10% best installations in that sector in the EU ETS.

In addition, an excise would be levied on the production of basic materials in the European Union and, as a CBAM, on the import of materials (also as part of manufactured products) into the EU to ensure that there is a carbon price on all goods sold in the EU. For **EU producers of basic materials**, the excise is calculated as the weight of the material multiplied with a material-specific reference value (e.g. reflecting the level of free allowance allocation granted to the production process of the material and, where relevant, its input factors) and the EU ETS allowance price. Excises are commonplace for goods such as tobacco, alcohol and gasoline.

Alternatively, a charge (or "climate contribution") that is closely linked to the EU ETS could be imposed, the revenue of which would go to special fund rather than the general budget (see Ismer and Haussner 2016). While diverging in the technical details and the legal basis (see Section 5.6.6), both the excise duty and the charge (climate contribution) have equivalent economic effects. We will therefore discuss both instruments jointly and use both terms largely synonymously, where no differentiation is required for legal reasons.

[28] Release for consumption is a technical term defined in Article 7 of the EU Excise Tax Directive. It can be roughly described as the time when the product leaves the tax warehouse and is transferred to the consumption sphere.

A CBAM for an excise would ensure that the excise is destination-based, i.e. imports would also be liable for the excise and the excise would be waived for exported goods[29]. Just as for other destination-based market-based regulation or tax, the scope of application is limited to products sold in the jurisdiction (*"at destination").* This requires a CBAM both for imports and for exports:

- For **imports**, the destination principle would be achieved by making the importation of basic materials, as well as goods containing a significant share of such materials, a taxable event. The importation would thus create the same liability as if the materials had been produced in Europe, i.e. dependent on the weight of the material (independent of the actual production process). A *de minimis* rule could limit administrative effort down the value chain by (i) excluding certain product categories so that the liability is waived for a set of PRODCOM[30] import categories altogether, as well as (ii) waiving the charge for the importation of small quantities of materials or of goods containing such materials.

- **Exports** of materials and manufactured products, on the other hand, would not be subject to the excise. Hence, as with the excise on alcohol or gasoline, firms could request a duty suspension for the liability created upon production or import. Thus, the excise could be waived where materials, including as part of products, are exported. A payment is due once the good is sold to a firm or consumer not registered for duty suspension (Ismer et al. 2016). This technical concept typically implies that the charge is paid by the last major supplier in the value chain.

While the excise itself applies irrespective of the origin of the product, precisely the adjustments for imports and exports rather than the free allocation are what constitutes the CBAM. This becomes clear when contrasted with the current rules of the EU ETS: Current free allocation is generally, and rightly so, not considered to be a CBAM. Introducing an excise without border adjustments would imply that only domestic products would be subject to the excise and that domestic products would be subject to EU carbon pricing even if sold abroad. The border adjustment mechanism implies that imports are also subjected to the excise, whereas exports are relieved[31].

[29] It is important to note that the excise itself is not the CBAM. Rather, the CBAM lies in the adjustment of the excise at the border. The adjustment is necessary to ensure that all products sold in the European Union are subject to the same level of excise.

[30] PRODCOM is a survey that provides statistics on the production and sale of about 3,900 industrial goods and services. PRODCOM mainly covers manufactured goods, but also includes some industrial services (mining, quarrying and manufacturing). Annual PRODCOM statistics include physical volume (kg, m2, number of items, etc.) of production sold, as well as the value of production sold. Products are detailed at an eight-digit level: The first four digits refer to the equivalent class within the Statistical classification of economic activities in the European Community (NACE), and the next two digits refer to subcategories within the Statistical classification of products by activity (CPA).

[31] Admittedly, as already noted by the GATT 1970 Working Party Report on border tax adjustments, the term "border adjustment" is somewhat open to confusion because it implies that the adjustment necessarily takes place at the border whereas this is not the case. In fact, under certain tax systems exports never become liable to tax and so no adjustment actually takes place at the border; in addition, under certain tax systems imports are usually taxed, as is home production; by the importing country at the time they are sold by registered traders to other traders or consumers, and so the adjustment takes place after the goods cross the border. For this reason, it is recommended that the term "border tax adjustments" should be replaced by "tax adjustments applied to goods entering into international trade". For the sake of brevity, subsequent references in this report are to "tax adjustments".

3.2.6. Option 5: Carbon added tax (CAT) with CBAM

Option in Brief

Depth of value chain: Basic materials, components and final products

Coverage of CBAM: Imports and reimbursement for exports (symmetric)

Free allocation in the EU ETS: No (full auctioning of allowances)

Mode of payment: EU ETS coverage for domestic producers plus payment of tax for additional emissions at each production step; imports at reference value or actual emissions

Reflection of actual emissions in carbon pricing: Yes (tracing of incurred costs within EU and abroad; importers may opt for default values)

The fifth option is a so-called carbon added tax. It would consist of a fixed amount of money paid at each production step for every additional tonne of CO_2 equivalent emitted. Such a carbon added tax would seek to ensure consistent carbon pricing for all emissions along the value chain associated with a covered product or, potentially, service. In contrast to the excise duty, a payment would become due at every production step involving carbon emissions. While ultimately the final consumer would pay the CAT, producers would collect it in all intermediate production steps. It would thus reflect the fact that carbon emissions occur all along the value chain.

The tax liability would correspond to the **product carbon footprint using the cradle-to-gate logic** (see Section 5.2.2,), i.e. all direct and indirect carbon emissions from the production processes along the value chain (upstream emissions). From such a liability, carbon added tax incurred and paid under previous steps could be deducted. In a purely domestic setting, this implies that where all previous transactions in the value chain had been subject to the full carbon added tax, the tax liability for this transaction would be limited to emissions associated with the last stage. By contrast, where for some reason the previous steps had not been subject to the full carbon added tax, the tax would have to be made up for emissions at the following step.

A CBAM would ensure that the CAT is **destination-based***.* Again, the scope of application would be limited to products sold in the jurisdiction (*"at destination").* This requires a CBAM both for imports and for exports: In line with the destination principle, imports of all goods would be liable for the carbon added tax at the reference value for the product or, where they are reported, actual full emissions, giving rise to complex verification needs. In order to avoid potential for fraud, the carbon footprint should irrefutably be deemed to correspond to the reference value where imports rely on the reference value. The carbon added tax accumulated over the different production steps would be refunded for exports. Alternatively, a system of duty suspension of the carbon added tax could be implemented (similar to Option 4). The liability would then be passed on along the value chain, but no actual tax payment would be made while the products would be held under duty suspension. This approach would imply that the carbon added tax liability could be acquitted upon exportation. In order to avoid export shuffling, i.e. the allocation of carbon-intensive production to exports due to reimbursement of incurred carbon costs, refunds could be capped at a reference value.

The **relationship with the EU ETS is not fully clear**. A CAT should not be considered as a replacement for the EU ETS. This is due to the fact that the current discussion rightly focuses on a complement for the successful EU ETS, not a substitute. Thus, for domestically produced products, in order to ensure integration into the existing EU ETS and a sufficiently broad scope for the EU ETS, the operators of installations currently taking part in the EU ETS would continue to do so. The carbon added tax would not apply to the emissions covered by the EU ETS but be confined to additional emissions from every subsequent production step not covered by the EU ETS. Yet it must be seen that the CBAM could, if at all, apply only to additional costs under the CAT. This begs the question of a CBAM for the EU ETS.

There are certain, albeit **limited, parallels of the CAT with the value added tax**. First, comparable to valued added tax (VAT), credit is granted for tax paid under previous steps. Second, CAT is also a tax on consumption. Ultimately, the consumer would pay for the entire carbon footprint of a final product - as with VAT, the producers only collect the carbon added tax, but are deemed to shift the economic incidence to the final consumers. However, these parallels should not hide the fact that the information requirements for CAT are far greater than for VAT: The tax base for VAT is the product price, whereas the CAT needs information on emissions. Moreover, for VAT purposes, the information on transactions in which the taxpayer is directly involved (received supplies for input credit and effected supplies for tax) is sufficient in most cases. By contrast, the carbon added tax requires information on the taxpayer's own production emissions, as well as on all previous transactions and emissions. Companies would thus have to trace the entire previous value chain. Tracing would not only apply to the physical inputs into a production stage and any (suspended) tax liability, but also the full carbon footprint of these inputs. This means that carbon added tax invoices would have to be generated, which contain information on the carbon footprint of the good and of carbon added tax paid or suspended. Furthermore, there would have to be a careful tracing of inputs, showing which specific input goes into which output where the inputs are physically identical, but have a different carbon footprint. This would necessitate an exhaustive accounting of the carbon emissions, starting from the earliest steps of the production. These requirements significantly go beyond the requirements both under current VAT and under the excise proposed under Option 4, and even further beyond the requirements of Options 1 to 3.

3.3. Assessment criteria and their application to the options

This section describes assessment criteria for the different options for intervention. The assessment criteria are based on the most important policy objectives ("PO"), secondary objectives ("SO") and requirements ("R") for CBAM or alternative measures, as also outlined in the intervention logic (Chapter 2). In a second step, several indicators are proposed (Section 3.3.2) that measure the extent to which the anticipated performance of different intervention options can help address these policy objectives, while being aligned with legal requirements and feasible in practice.

3.3.1. Objectives and requirements

PO1: Support reduction of greenhouse gas emissions in the EU

The CBAM should help the EU to address climate change by reducing greenhouse gas emissions in the context of increasing EU climate ambitions. A consistent carbon price is a suitable means to improve both the effectiveness and efficiency of EU climate policy. This can be achieved by strengthening the carbon price signal in the EU for sectors covered by the EU ETS. While the current system of free allowance allocation would provide an effective carbon leakage protection if previous allocation levels continued (see Section 3.4.2), it partially mutes the carbon price along the value chain, leading to limited incentives for an efficient use of carbon-intensive materials, as well as substitution by lower-carbon alternatives (Section 3.4.1). The current free allocation thus tends to create a level playing field with international competitors by lowering the carbon price to the lower level (see Droege et al. 2009). Conversely, a CBAM would make it possible to ensure a consistent carbon price for all products concerned, whether domestically produced or imported. A consistent carbon price would provide adequate carbon price incentives to support investments in climate-friendly production, use and recycling of materials. Thereby, the CBAM is expected to make a significant contribution towards the achievement of the EU's Green Deal objectives, including an emission pathway towards climate neutrality by 2050. In doing so, a CBAM or alternative measure, should implement the principle of consistent carbon pricing, i.e. avoid both under- or overpricing of GHG emissions.

PO2: Avoid carbon leakage risk

A central objective of the CBAM is to ensure that the EU's increased climate targets are not undermined by the unintended consequence of an increase of emissions outside of the EU. Consequently, the change from free allowance allocation towards a CBAM or alternative measure should result in a high level of protection against carbon leakage. Adequately addressing concerns about carbon leakage risks is thus essential to enhance regulatory credibility of the EU ETS and the resulting carbon price.

Carbon leakage risks may stem from three different sources. First, such risks could originate from asymmetric carbon costs between EU and non-EU producers, which might incentivise relocation of investment or production out of the EU and thus relocation of emissions to other regions rather than their reduction. Second, even if there are no direct asymmetries in the costs of current production, there may be investment leakage in case the regulatory environment for an investment into climate-neutral production processes is inadequate. Third, resource shuffling (see Box 1) may also undermine carbon leakage protection: An allocation of low-carbon resources from foreign producers to imports into the EU may lower the carbon costs these importers face and therefore undermine the carbon leakage protection which the CBAM provides, without leading to a decrease of global emissions.

Box 1: A note on resource shuffling

Incentives for resource shuffling (see definition in 3.1) exist for any emissions-related policy that includes traded goods (e.g. CBAM or product standards), where carbon intensity of imported or exported products does not rely on default values for the carbon intensity of products, but on actual emissions. For a CBAM, non-EU producers have an incentive to re-route carbon-intensive products to other markets in the world economy to avoid the penalty imposed by the tariff, which may increase the global cost of emission reduction (Böhringer et al. 2018). For CBAM, such incentives may exist both for imports of basic materials (or manufactured products containing those materials) and reimbursement upon export, respectively. First, if importers are allowed to challenge the default values of carbon-intensive products, they may allocate less carbon-intensive products to the European market. Since such products would bear lower carbon costs, this would allow non-European producers to gain market shares at the expense of European producers. This would result in a reduction of EU emissions at the expense of an increase of international carbon emissions. If the carbon intensity of the marginal international plant exceeds the carbon intensity of the EU marginal plant, this would imply an overall increase of global emissions. Second, if European exporters are reimbursed according to the carbon costs incurred upon production, they may allocate more carbon-intensive production to export markets, while retaining cleaner production processes for sale in the EU (Pauwelyn and Kleimann 2020). This would allow producers to avoid facing full carbon costs for this share of their products.

Resource shuffling can reduce the reported carbon intensity of imports (or increase carbon intensity of exports) and thus result in (partially) avoiding a charge imposed on imports or an increase of a refund obtained by exports. The following three mechanisms are potential forms of resource shuffling:

1. Attribution of low-carbon (high-carbon) input factors (low-carbon electricity, low-carbon heat, biomass) to imported (exported) materials;

2. Attribution of GHG emissions of a production process to co-products (e.g. slag, heat, flue-gases) to improve the reported carbon intensity of basic material production (unless strict MRV rules would

limit such approaches);

3. Attribution of shares of recycled material to imported or exported goods.

Such an attribution is in principle feasible at different levels:

a. At the level of the power system, low-carbon electricity can be attributed to the production of basic materials (extremely strong effect in case of aluminium, but electricity input is also relevant in other materials).

b. At the level of installations, low-carbon inputs (biomass, 'waste-heat') or effective use of co-products could be concentrated to individual installations, in order to deliver particularly carbon efficient outputs from an installation.

c. At the level of installations, production shares could be attributed to corresponding shares of the output (e.g. in blast oxygen furnaces for steel making, typically 20% of scrap steel is inserted and hence 20% of output could be labelled as recycled and hence low-carbon).

d. At the level of the manufacturing industry, unless material flows are precisely traced, low-carbon input factors may also be disproportionally attributed to exported products.

Although important, resource shuffling concerns have often been overlooked in the past, since much of the debate was informed by (i) discussions of the CBAM mechanism based on the example of the cement sector, which is probably the one sector with very limited resource shuffling concerns due to a linear and globally homogeneous production process with simple inputs and no co-products (other than the waste product CO_2); (ii) assessments based on comprehensive models (e.g. CGE) with limited detail on trade flows, which mostly assume homogeneous products and thus do not provide sufficient granularity to assess resource shuffling. Resource shuffling has emerged as an important problem in the Californian CBAM on electricity (see Section 6, Lo Prete et al. 2019, Mehling et al. 2019, Pauer 2018, Bushnell et al. 2014).

SO1: Support international climate action

CBAM should create a plausible example of successful national policy implementation towards achieving climate and broader social objectives, which may inspire third countries to implement similar policies of their own (policy diffusion). This means that CBAM should create favourable conditions for exports from countries and companies with effective climate policies and actions, so as to support their effort and encourage others to follow. The mechanism should minimise the risk to be seen or be deliberately portrayed as protectionism in the guise of climate policy, which could undermine the EU's credibility in global climate cooperation.

R1: Practical feasibility

The CBAM must be feasible in practice, ensuring a high degree of compliance with the obligations under the mechanism. Administrative and compliance costs should be as limited as possible, while still reaching the policy objectives.

3.3.2. Indicators

To assess to what extent the proposed mechanisms can meet the objectives and requirements, the following indicators are proposed*:*

PO1: Support reduction of greenhouse gas emissions in the EU

As outlined above, a consistent carbon pricing supports European actors in the transition towards climate neutrality. As indicators, we will assess whether the different options for intervention provide incentives for investments in:

- *Efficiency improvements for material producers.* Producers using conventional production processes for basic materials should have incentives to reduce the carbon intensity of production.

- *Climate-neutral production processes*. Materials producers need to be able to recover the costs of financing investments into and operating costs of climate-neutral processes. To this end, full carbon cost internalisation and cost pass-through is necessary so that investors in climate-neutral production processes can recover incremental costs (both CAPEX and OPEX).

- *Material efficiency and substitution with low-carbon alternatives.* A CBAM or alternative measures should encourage users of materials, such as manufacturers and the construction sector, to optimise the amount of material (e.g. using less materials in the production process) to enhance material efficiency. At the same time, there should be incentives to shift to alternative materials with lower embedded emissions. Prices of basic materials should therefore reflect the full carbon price, so that incentives for efficient material use and substitution are present.

- *Recycling*. The carbon price should also contribute to incentivise effective material recovery, sorting and recycling to enhance the resilience of value chains and support a shift to climate neutrality. Full carbon cost internalisation for basic materials is needed so that incentives for recycling are present.

PO2: Avoid carbon leakage risk

The degree of asymmetry in carbon pricing faced by European and non-European producers is evaluated as an indicator for carbon leakage risk both for basic materials sold within and outside of Europe, as well as for manufactured products sold in domestic and foreign markets. Moreover, assessments are needed to determine whether there are incentives for a relocation of investment (investment leakage) and whether possibilities for resource shuffling exist.

SO1: Support for international climate action

In addition to the domestic incentives and viability of the approach, indicators assess the potential policy diffusion and the benefits for the EU if third countries pursue the approach in parallel with the EU. With respect to the international incentives, a narrative will discuss to what extent the mechanism creates incentives for material producers, manufacturing industry using materials and recycling industries in third countries for more climate-friendly investments. With respect to the mechanism creates incentives for material producers, manufacturing industry using materials and recycling industries in third countries for more climate-friendly investments. With respect to the potential political repercussions, the likely narratives will be listed together with (likely) groups advocating them.

R1: Practical feasibility

Administrative and compliance costs are evaluated for the different CBAM options based on their relative complexity, particularly with respect to requirements for monitoring, reporting and verification (MRV). Increased complexity translates into higher administrative and compliance costs. Conversely, these costs decline where established administrative structures, data, standards and benchmarks can be used.

3.4 Assessment of key elements of the options design

In this section, the reference case and the five different options discussed in Section 3.2 are assessed. In addition to the primary objectives, secondary objective and requirement, we also assess possible revenues from the different CBAM options. A carbon border adjustment mechanism was endorsed by the European Council as an own resource for the EU in July 2020. In the interinstitutional agreement signed on 16 December with the European Parliament and the Council, the Commission committed to table by June 2021 a proposal for an own resource based on a carbon border adjustment mechanism. The CBAM should therefore generate sustainable revenues, which could help for example to finance the transformation to low-carbon industrial processes or support international climate action as well as potential further EU policy objectives.

3.4.1 Primary objective 1: Support reduction of greenhouse gas emissions in the EU

This primary objective looks at the incentives from carbon pricing for European actors. Table 3-2 provides an overview of the results.

Table 3-2: Summary of assessment of PO 1: Support reduction of greenhouse gas emissions in the EU

	Current ETS	Complementing measures to EU ETS					
CO_2 price incentives for...	***(BAU) Continued and declining free allocation***	***(1a) CBAM on imports with auctioning (basic materials only) at a reference level***	***(1b) CBAM on imports with auctioning (basic materials only) at the level of actual emissions***	***(2) CBAM on imports complementing free allocation (basic materials only)***	***(3) CBAM on imports and exports with auctioning (materials also in finished products)***	***(4) Excise including CBAM and free allocation (materials also in finished products)***	***(5) Carbon added tax including CBAM (materials also in finished products)***
Material producers (efficiency improvements) in the EU	Incentive from EU ETS price	Incentive from EU ETS price		Incentive from EU ETS price	Incentives from EU ETS price where products sold domestically, no incentive for reductions below the default value for exports	Incentive from EU ETS price	
Material producers (climate-neutral production) in the EU	Clean processes would require free allocation, which is allocated to conventional processes and is declining. No credible long-term perspective for continued free allocation to clean processes	Limited carbon cost pass-through from conventional production also limits the benefits from emissions savings that competing climate-neutral producers can monetise		Declining free allocation and limited carbon cost pass-through limit incentives		Free allocation to clean processes covers incremental costs; combination with excise makes this a credible long-term perspective	Incentives from EU ETS price where final products sold domestically, no incentive for exports
Manufacturing and construction industry in the EU	Only fraction of carbon costs passed through to material prices due to free allowance allocation and international competition	Incentive from EU ETS price, but weakened through competing imports of components that are not covered		Free allowance limits pass-through in the short term; imports weaken incentive from EU ETS price as free allocation phased out	Incentives from EU ETS price where products sold domestically, no incentive for exports	Full incentive for efficient material use and substitution for products sold domestically, no such incentives for exported products	
Recycling in the EU	Limited incentives since production of materials not subject to full carbon costs	Incentives as carbon costs are borne by competing primary production process, may be reduced to the extent that international competition limits cost pass-through		Limited short-term incentives; increase with level of auctioning	Full incentives, since production of materials is subject to full carbon costs	Full incentives possible	Full incentives, since production of materials is subject to full carbon costs
Summary	Largely inconsistent carbon pricing incentives for material efficiency, recycling (cement, plastic), and clean processes	Reduced carbon price incentives for material efficiency and clean processes		Largely inconsistent carbon pricing incentives for material efficiency, recycling, and clean processes in short term; increase as free allocation is phased out	Full carbon price incentives for domestically sold products, limited incentives for exports	Full carbon price incentives for efficient/ clean material production and recycling, no downstream incentive for efficient material use in exports	Full carbon price incentives for domestically sold products, limited incentives for exports

Objective or requirement achieved

	Objective or requirement not fully achieved
	Objective or requirement not achieved

Business as usual: EU ETS with continued and declining free allocation

Despite the existence of free allocation, producers face full incentives to reduce their emissions. The reason is that there is an opportunity cost of using free allowances: Efficient producers can sell surplus allowances on the market, and inefficient producers are liable for purchasing additional allowances for emissions exceeding the free allowance allocation.

However, there are drawbacks of the free allocation of allowances and to financial measures to compensate for indirect emissions to the producers deemed to be at the risk of carbon leakage. Producers from these sectors effectively face a less stringent carbon price than sectors without such risk, which leads to muted policy signals along the value chain and downward pressure on allowance prices (Grubb and Neuhoff 2006; Mehling et al. 2019). For instance, only an indeterminate part of the carbon price will be reflected in material prices due to the combination of international tradability of materials and competition in international product markets, as well as the linkage of free allowance allocation to production volumes; the share of cost pass-through may also differ significantly between sectors (Branger et al. 2015; de Bruyn et al. 2015; Sato et al. 2015; Martin et al. 2016; Naegele and Zaklan 2019; Neuhoff and Ritz 2019). The consequence of this limited cost pass-through is a downward levelling of the carbon price, since carbon costs at the benchmark level are not fully reflected in materials prices (Droege et al. 2009).

Hence, the carbon price provides only limited incentives for an efficient material use and substitution with less carbon-intensive materials (Böhringer et al. 2019; Neuhoff & Ritz 2019). The lack of full carbon costs reflected in primary produced materials and products also implies that the carbon price is not very effective in creating incentives for selling recycled materials and products.

To cover investment and incremental operational costs of climate-neutral processes, operators of such installations would need a sufficient level of free allowances. Yet the current EU ETS does not provide a reliable investment framework for this. First, the level of allowances available for free allocation declines over time and will largely be required for conventional processes. Hence only limited and declining volumes remain, which are insufficient for increasing production volumes from climate-neutral production processes. Governments would therefore need to use general budget resources to buy allowances in the market to meet the additional demand for clean production processes or to pay directly for their incremental costs. Full dependence on subsidy from the general budget is not an active basis on which to build an investment strategy. In sum, the limited cost pass-through of the business as usual (BAU) scenario means that significant GHG mitigation potentials are foregone[32]. Moreover, the declining free allowance allocation implies that there is no business case for long-term investments into breakthrough technologies.

Options 1a/b: CBAM on imports of basic materials with full auctioning

As can be seen from Table 3-2, carbon pricing incentives are identical under options 1a (use of default values/reference values only) and 1b (CBAM for imports at the level of actual emissions). As under free allowance allocation, producers of basic materials have an incentive for efficiency improvements from the EU ETS price, since a less carbon-intensive production requires the purchase of fewer EU ETS allowances and surplus ETS allowances can be sold in case production efficiency goes beyond the EU ETS benchmark. In principle, prices of basic materials and components should reflect these increased production costs. However, a set of

[32] For example, the International Resource Panel of the UNEP calculates that through material efficiency strategies 35-40% lifetime GHG emissions savings would be possible from buildings and cars in the G7 in 2050 (IRP 2020).

factors may moderate the price increase. First, exports of basic materials may decline with the asymmetric cost increase for European producers, resulting in a domestic surplus capacity and downward pressure on domestic material prices. Second, as imports and exports further down the value chain will not be subject to the CBAM, product prices further down the value chain may also not fully reflect carbon costs due to competition with international products that may bear no carbon costs, which would also put downward pressure on input prices for basic materials. Third, in option 1b, resource shuffling may result in significant volumes of imports that receive a rebate from the CBAM and can thus put downward pressure on domestic material prices. As a result, the carbon price will be more effective (less distorted) than in the reference case, but is unlikely to be fully consistent in order to incentivise efficient material use and substitution of carbon-intensive materials with alternative materials.

In principle, the CBAM on imports provides incentives for climate-neutral production processes, since the costs of conventional material production and imports increase with the carbon price. However, there is uncertainty as to what extent the effects described above might limit the carbon price level reflected in basic material prices and thus limit the effectiveness of the carbon price signal to foster the investment needed for supporting climate-neutral production processes and recycling. Increased recycling incentives may also have unintended consequences for the steel and aluminium sector (see Box 2 below).

Option 2: CBAM on imports of carbon-intensive materials complementing free allocation

The incentives of a consistent carbon pricing in Option 2 are a mixture of the reference case and Option 1. The relative weight of these options changes over time and depends on the credibility of the transition process from free allowance allocation to full auctioning. The lower the level of free allowance allocation, the more effective will be the carbon price in incentivising material efficiency, recycling, and clean processes.

For material producers, there are full incentives from the EU ETS price as in the BAU and under Option 1. Incremental costs of climate-neutral production processes cannot be covered from a declining level of free allocation limits, since cost pass-through is uncertain and producers thus cannot rely on higher materials prices to pay these costs. Recycling incentives increase with a declining free allocation of allowances, since the costs of primary production increase relatively more than the cost of recycled materials as free allocation is phased out.

Option 3: CBAM on imports and exports of carbon-intensive materials including as part of products with full auctioning

In contrast to the previous options, whenever materials or final goods containing basic materials are sold domestically, the EU ETS price fully incentivises both efficiency improvements of the production of basic materials and efficient material use and substitution: Due to the wider product coverage of Option 3, producers can more easily pass carbon costs along the value chain. Domestic producers thus also face full incentives for implementing climate-neutral production processes.

For exported goods, however, the incentive is limited to inefficient producers of basic materials below the production efficiency standard of the default value. The reason is that exported goods, which are less carbon-intensive than the default value, under this option receive a rebate at the border at the level of actual product emissions to avoid granting subsidies. This implies that inefficient exporters profit from efficiency improvements until they reach the default value, but there is no incentive for emission reductions below this default value.

Consequently, efficient exporters do not profit from a lower emissions intensity relative to the default value. This is especially problematic for climate-neutral production processes, since producers can only recover a small fraction of the incremental costs when products are exported. Climate-neutral production processes are thus supported only to a very limited extent for exported goods.

Similarly, manufacturers and the construction industry profit from an efficient material use and substitution when products are sold domestically, yet for exported goods there is no such incentive. On the other hand, there are full incentives for the recycling of basic materials covered by the CBAM, since the production of materials is subject to full carbon costs.

Option 4: Excise including CBAM on carbon-intensive materials including as part of products and continued free allocation

Adding an excise on carbon-intensive materials in addition to the EU ETS ensures a consistent carbon price signal along the value chain even in the presence of free allocation. Free allocation is retained in order to ensure consistency: Without such free allocation, European manufacturers would face a double charging of carbon prices, namely from buying allowances for materials production under the EU ETS, as well as the charge on the emissions embedded in products.

Since the excise is directly proportional to the weight of a material, it does not change relative prices of "like" materials produced with different production processes compared to the business as usual scenario of an EU ETS with free allocation. However, upstream EU ETS price incentives for production efficiency remain in place as under Options 1 and 2, such that materials producers are rewarded for decreasing the emissions intensity of production. In addition, the excise introduces full incentives for an efficient use of materials and substitution with low-carbon alternatives for construction and manufacturing: Free allocation alone (BAU) reduces carbon costs reflected in material prices by a share of the value of the allowances allocated for free. However, the excise reinstates this carbon price incentive by creating a parallel liability for all products sold for final use in the EU. As a result, the excise ensures that the reference carbon intensity of basic materials is reflected in product prices where products are sold domestically, in addition to the existing upstream incentives from the EU ETS. Only where products are exported, such incentives are not in place[33]. Should third countries also implement a similar scheme, then this would also ensure full incentives for material efficiency and use in exported products.

As the liability for the excise would also be created where materials are produced with climate-neutral production processes, these production processes would then also qualify for free allowance allocation at the level of the liability to finance incremental costs. Thus, the EU ETS carbon price signal would also provide an effective incentive for climate-neutral production. In contrast to the reference case, it is plausible that the level of free allowance allocation can either be maintained, or climate-neutral processes be financed by an alternative instrument. The reason is twofold. First, there is a need to improve the effectiveness of carbon pricing, since a consistent carbon price is reinstated with the excise. Second, the excise generates significant revenue (Section 3.4.5), which is foregone in BAU by not auctioning free allowances. Part of this revenue can credibly be used to continue free allocation or finance incremental costs of climate-neutral processes persistently with alternative ways of funding.

[33] Since the liability is acquitted for exports, the prices of exported goods do fully not reflect the carbon costs of basic materials at the benchmark level (only to the extent that upstream carbon costs are passed through). Nevertheless, the upstream incentives for the production of efficient and low-carbon materials remain in place.

The excise can be designed to provide adequate incentives for recycling in sectors where recycling is currently economically less viable (Box 2).

Box 2: Comparing recycling incentives

Improved sorting, collecting and secondary production to replace the primary production of materials, offers potentially significant emission reductions and energy savings, as well as benefits from reduced resource needs and enhanced resilience of value chains through the substitution of resource imports by using locally recycled materials (Chiappinelli et al. 2020). The EU circular economy strategy aims to contribute to the realisation of these potential improvements.

Consistent carbon pricing can make an important contribution; the impact will likely differ across materials. We illustrate this with examples of three groups of materials.

Cement clinker is combined with sand and gravel to form concrete. Concrete from the demolition of buildings and infrastructure is increasingly reused primarily as filling material to substitute for gravel, motivated by increasing costs and constraints on depositing demolition waste. Technologies for separating re-processing clinker components in concrete make it possible to recycle concrete and to substitute for the carbon-intensive primary production of clinker. The economics improve with the costs for depositing of concrete and if the complete carbon costs are reflected in the price of the (competing) primary produced cement clinker.

Under a combination of free allocation and the international trade of clinker, only a fraction of carbon costs is reflected in clinker prices. Instead, consistent carbon pricing is necessary – clinker costs need to fully reflect the carbon costs of clinker production. Recycled cement can thus benefit from the higher price level to cover costs. Together with savings on waste deposit charges, this could create the business case for large-scale cement recycling.

Consistent carbon pricing providing adequate incentives for recycling in the cement sector can be achieved either with a **shift to full auctioning under EU ETS in combination with a carbon border adjustment mechanism (CBAM)** or with **continued free allocation in combination with an excise liability created with the production of clinker**. In the latter case, recycling facilities could either benefit from free allocation based on the conventional primary production (in order to create additional recycling incentives) and be liable to the excise. Alternatively, since cement recyclers are typically small, a *de minimis* capacity threshold could be introduced below which recyclers could be excluded from both free allocation under the EU ETS and the liability to pay the excise.

Less than 30% of **plastic** waste is recycled in EU[34]. The majority of the collected plastic (39% of the total plastic waste) is "thermally recycled", e.g. burned in waste incineration plants. With higher plastic recycling targets and harmonised rules regarding the calculation of recycling quotas as part of the Circular Economy Package in 2018[35], the EU has started a renewed effort to increase the share of plastic waste that is mechanically or chemically recycled towards new plastic.

As in the case of cement, ensuring plastic costs fully reflect carbon costs can create an important incentive for the different routes of plastic recycling, while avoiding distortions of the competition between mechanical and different chemical recycling routes. The same policy options as in cement (full auctioning with CBAM or continued free allocation at the primary benchmark for material recyclers with excise) can effectively contribute to consistent carbon pricing.

A difference to cement, however, is that a large share of the carbon footprint of plastic does not result from the primary production process, but from the end-of-life treatment. While CO_2 emissions during the production process amount to approximately 1.8 to 3.5 tonnes per tonne of plastic (depending on the type), an additional 2.7 tonnes of CO_2 are emitted when plastic is incinerated.[36] These emissions can be avoided through plastic recycling, but are typically not priced, since incineration plants are exempt from the EU ETS in most Member States. It will therefore be important that these emissions are priced, and that the costs are made relevant for production and purchase choices, for example using advanced disposal fees.

Ensuring consistent carbon pricing by including emissions from plastic waste incineration in Extended Producer Responsibility (EPR) schemes is important both for improved recycling incentives and for fair

[34] Around 25.8 million tonnes of plastic waste are generated in Europe every year. Of the less than 30% of plastic waste collected for recycling, a significant share leaves the EU to be treated in third countries, where different environmental standards may apply (EC, 2018). For plastic packaging waste, the estimated recycling rate in the EU is 42% in 2017 (EUROSTAT, 2019).

[35] DIRECTIVE (EU) 2018/852 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 amending Directive 94/62/EC on packaging and packaging waste.

[36] The emissions of the primary production process are based on the ecoinvent 3.7 database. End-of-life emissions are calculated based on the carbon content of plastic, using the approach and default values established in the IPCC guidelines (2006a and 2006b).

competition with other materials like steel or aluminium. This could happen on the basis of an eco-modulation of the financial contribution that producers pay to comply with an EPR scheme[37], which are in place across EU Member States in a variety of forms. The corresponding revenue could thus either be used to cover carbon costs from incineration, or to support improved collection and sorting.

Steel and aluminium production from scrap is profitable without additional carbon price incentives because secondary material production based on scrap is simple and more energy efficient than primary material production[38]. Consequently, despite a lack of additional price incentives, scrap prices are high and major shares of these materials are already recycled.[39] Under the EU ETS, the carbon price signal is currently largely muted, as primary and secondary production of steel and aluminium benefit from free allowance allocation at the benchmark for primary and secondary production, as well as power price compensation that largely compensate primary and secondary processes for the respective incremental carbon costs. Hence, the EU ETS only creates very limited incentives for recycling.

In contrast to plastics and cement, incentivising recycling through a move to full auctioning with CBAM might introduce unintended consequences for the production of steel and aluminium. In such a scenario, all production processes would bear their full carbon costs. Costs for secondary production processes would then increase by far less than primary production processes. This would translate into an increased profitability of secondary production processes and hence increased demand for steel and aluminium scrap in Europe. The result would be a reduction of steel scrap exports or even steel and aluminium scrap imports. The increased secondary production could replace primary production in the EU, while the reduced availability of scrap outside of the EU would likely trigger increased primary production outside of the EU (carbon leakage)[40].

In a scenario with continued free allocation combined with an excise charge, the excise would not change the relative costs of primary and secondary production. This would avoid distortions to the international scrap trade. Since scrap is already recycled effectively, additional carbon price incentives for secondary production are not necessary.

Collecting and sorting scrap are neither incentivised by the combination of full auctioning and a CBAM, nor by the continuation of free allocation with an excise charge. These incentives could, however, result from higher scrap prices. In the case of cement and plastic, the corresponding scrap prices could indeed appreciate if secondary production is further incentivised in Europe because of a lack of tradability for cement (due to high transport costs), as well as the possibility to introduce regulation of trade of waste substances for plastics. In the case of steel and aluminium scrap, international trade is important to balance primary and secondary production capacities across countries and a ban on scrap trade is difficult to imagine. Applying instead a border carbon adjustment for scrap would raise challenges with respect to setting the specific carbon intensity to attribute to scrap, in particular at the time of import. More so, an adjustment on imports alone would not suffice, given the current large volume of steel scrap exports.

Therefore, in the case of steel and cement, due to the active international trade in scrap, it seems undesirable to create carbon price incentives for increased secondary production from scrap. They would however emerge in the case of a shift to full auctioning (with or without CBAMs). The result could be shifts of scrap trade flows, with very limited additional incentives for collection and sorting. Continued free allocation in combination with an excise does not result in such distortions.

Option 5: Carbon added tax including CBAM

European material producers face full carbon price incentives for both efficiency improvements and carbon neutral production, but only if materials or final goods are sold within the EU. There are also full incentives for an efficient use and substitution of materials in the manufacturing

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[37] This type of policy effort corresponds to the amended Waste Framework Directive (Directive 2018/851/EU) with the eco-modulation of the financial contribution paid by the industry to comply with its extended producer responsibility (EPR) obligations (Art. 8a). The EPR principle aims to provide producers with incentives to internalize environmental costs throughout the product life-cycle, including product eco-design. (OECD, 2016).

[38] The main challenge for the recycling of steel is the 'pollution' of scrap with different metals. It precludes the use of recycled materials for high value applications. Currently these applications are served by primary materials, and hence there is limited incentive for market participants to act – pointing to the importance of improved policies on product design and waste treatment to avoid a pollution of the future stocks of materials.

[39] Over 90% of aluminium in automotive and buildings is recovered for recycling, with only 60% of packaging and 75% of beverage cans. The recycled aluminium (pre- and post-consumer scrap) represents 36% of the aluminium metal supply in Europe (European Aluminium, 2020). The proportion of steel scrap used in crude steel production in EU-28 is 55.9% in 2018 (BIR, 2019).

[40] In a scenario with export rebates through CBAM, the increased secondary production in the EU could also result in an increase of net-exports replacing secondary production outside of the EU.

and construction industry whenever products are sold domestically. Moreover, there are full recycling incentives, since producers of materials face full carbon costs.

If a share of products is exported, the incentive declines proportionally. Since exports are reimbursed at the level of incurred costs, there is no incentive for goods exported outside of the EU.

3.4.2 Primary objective 2: Avoid carbon leakage risk

This section analyses the effect of the different CBAM options on materials and product sales (as a proxy for emissions associated with these products) within the EU and abroad, incentives for a relocation of investment and resource shuffling. Table 3-3 gives an overview of the share of exports for different basic materials that may potentially be included in a CBAM[41].

Table 3-3: Primary production, imports and exports of selected basic materials

	Total primary production [Mt]	Imports [Mt]	Exports [Mt]	Export share [%]
Cement	152	5.2	11.5	8
Steel	159	46.6	29.4	18
Aluminium	7	8.1	3.1	46
Plastics	119	14.5	13.8	12
Pulp	21	8.1	6.3	31
Paper	88	6.1	18.3	21
Glass	127	3.8	2.6	2

EU-28 data for 2019. Imports and exports include semi-finished and finished materials as defined by Stede et al. (2021), which are similar to the definitions of basic materials and basic material products used in this report.

Sources: Calculations based on PRODCOM statistics from Eurostat, World Steel Association, Brown et al. (2019), US Geological Survey (2018).

Figure 3-1 shows relative cost increases for different goods containing significant shares of basic materials (by PRODCOM[42] category) along the value chain[43]. Cost increases are calculated based on a carbon price of 30 EUR/t and product benchmarks from the EU ETS, assuming full carbon cost pass-through along the value chain. This cost increase is divided by a NACE-specific ratio of gross value added (GVA) to turnover (reflecting the share of turnover that is value added). The resulting relative cost increase is an estimate of how much carbon costs would increase relative to the gross value added of companies. For the share of products sold internationally, under an import-only CBAM (Options 1 or 2) EU producers could only recover these additional costs if they are able to raise the prices of their exports. Alternatively, for domestic sales, Panels C and D may be viewed as an estimate of how much carbon pricing reduces margins, under the assumption that the companies face higher input costs (because the inputs are covered by a

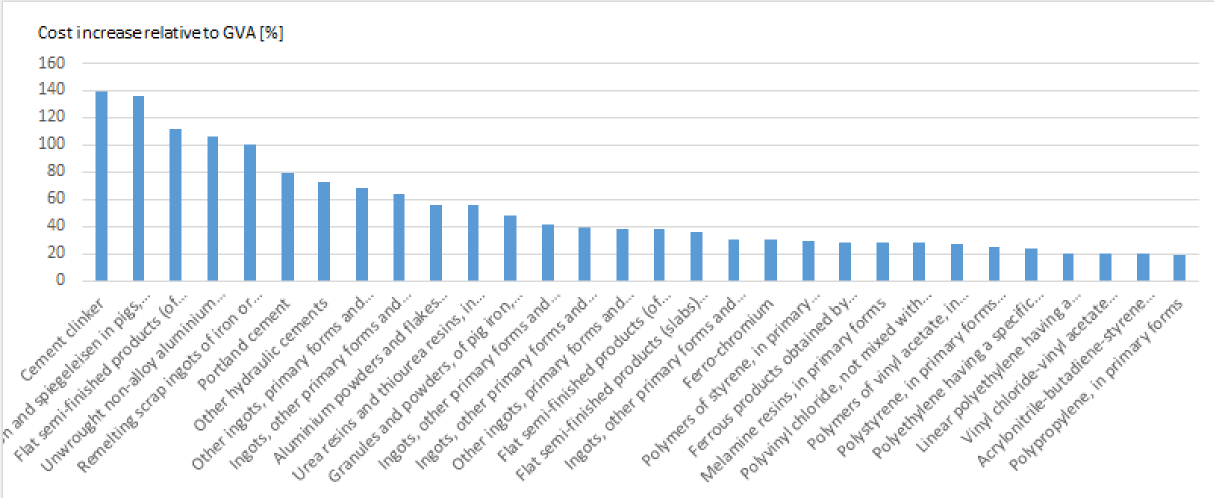
[41] The data shown in Table 3-3 is based on PRODCOM data at the product level. Using product-level data instead of more aggregated sectoral data based on NACE codes makes it possible to isolate basic materials and basic material products from manufactured products further down the value chain. However, gross value added is not available at the PRODCOM level. Information on the value of sales at the PRODCOM level may be misleading, since it includes the value of raw materials, which are mostly imported. It is therefore not included in the table.

[42] See footnote 30 for a definition of PRODCOM and the relation to NACE sectors.

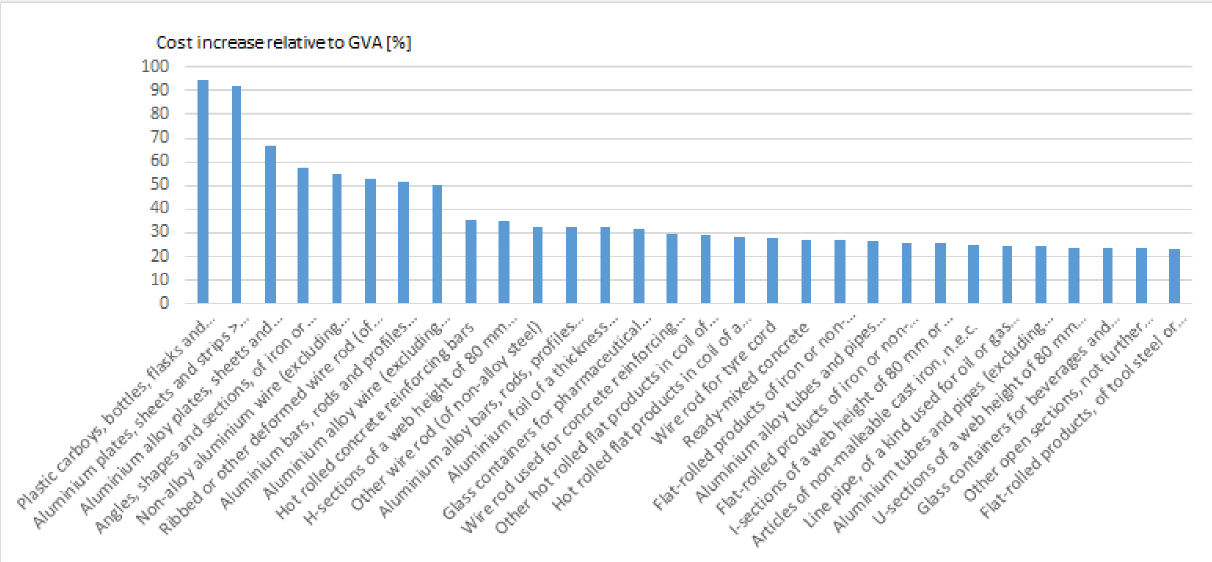
[43] Almost two-thirds of all PRODCOM categories (64 percent) contain relevant shares of cement, steel, aluminium, plastics, pulp, paper or glass.

CBAM), but cannot pass through the additional costs, because their products are not covered by a CBAM. Figure 3-1 is thus an estimate of the effect on margins of the cost increase relative to gross value added in a stylised highly trade-intensive global market competing in product prices.

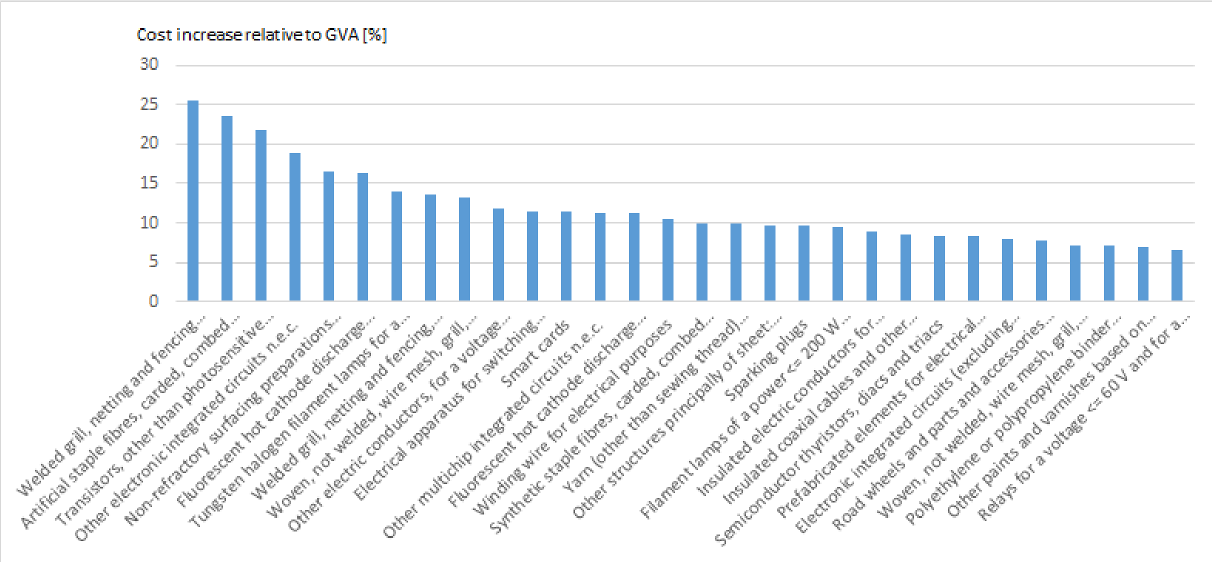
Panel A: Basic materials



Panel B: Basic material products



Panel C: Components of products



Panel D: Final products

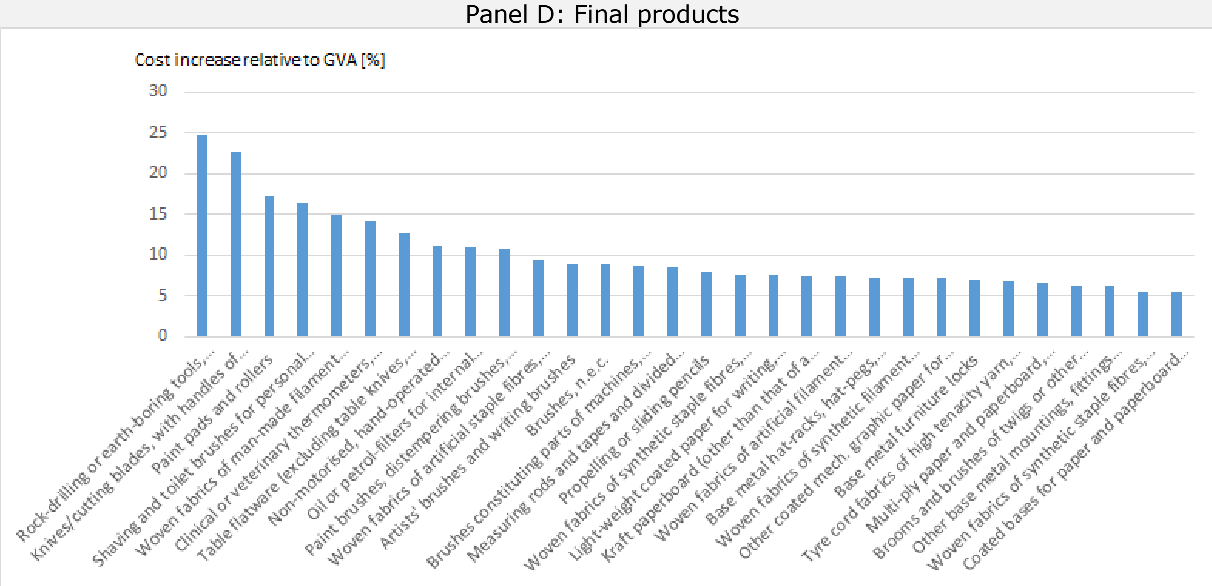


Figure 3-1: Increase of costs relative to gross value added according to embedded materials

Relative cost increases are calculated based on a carbon cost of 30 EUR/t and benchmarks of basic materials from the EU ETS under the assumption of full carbon cost pass-through. Basic materials covered include cement, steel, aluminium, plastics, pulp, paper and glass. For plastics, an emissions intensity of 1.5 tonnes of CO_2e per tonne of material is assumed. Categorisation of goods as defined by Stede et al. (2021).

Table 3-4 summarises the assessment on carbon leakage risks.

Table 3-4: Summary of assessment of PO 2: Avoid carbon leakage risk

	Current ETS	Complementing measures to EU ETS					
Potential source of leakage	***(BAU) Continued and declining free allocation***	***(1a) CBAM on imports with auctioning (basic materials only) at a reference level***	***(1b) CBAM on imports with auctioning (basic materials only) at the level of actual emissions***	***(2) CBAM on imports complementing free allocation (basic materials only)***	***(3) CBAM on imports and exports with auctioning (materials also in finished products)***	***(4) Excise including CBAM and free allocation (materials also in finished products)***	***(5) Carbon added tax including CBAM (materials also in finished products)***
Material sales in EU	Leakage risk currently avoided, but could result if revised ETS cap results in reduced availability of free allowances for industry and higher carbon prices	Risk of substitution with less carbon efficient imports at level of semi-finished products		Risk of substitution with imports at level of semi-finished products in medium term	Leakage risk avoided if no resource shuffling	Leakage risk avoided	Leakage risk avoided if no resource shuffling
Material sales abroad		Risk of substitution of clean products by less efficient foreign production		Risk of substitution with foreign production in medium term			
Product sales in the EU		Risk of substitution of EU products bearing carbon costs with potentially more carbon-intensive imports lacking such costs		Risk of substitution with imports in medium term			
Product sales abroad		Risk of substitution of clean exports by less efficient foreign production		Risk of substitution with foreign production in medium term			
Relocation of investment	Tightening emission budget inhibits conventional investment in the EU; lack of consistent carbon pricing framework inhibits investment in climate-friendly options in EU						
Resource shuffling	No incentive for resource shuffling	Resource shuffling avoided since no option for importer to deviate from default values for imports	Foreign producers may increase production with carbon-intensive products (at the margin) to realise profits possible by allocating clean energy sources/clean production processes/recycling to EU exports	Limited incentives for resource shuffling as long as levels of free allocation are high; increasing risk as free allocation declines	Foreign producers may increase production with carbon-intensive products (at the margin) to realise profits possible by allocating clean energy sources/clean production processes/recycling to EU exports	No incentive for resource shuffling	Foreign producers may increase production with carbon-intensive products (at the margin) to realise profits possible by allocating clean energy sources/clean production processes/recycling to EU exports

Summary	Short-term leakage risk avoided but could result from tightening ETS cap; lack of perspective could trigger relocation of investment	Resource shuffling risks avoided; however, significant risk along value chain and in export markets	Resource shuffling may erode leakage protection; significant risk along value chain and in export markets	Short-term leakage risk avoided, but increases as free allocation phased out; inconsistent investment framework could trigger relocation of investment	Resource shuffling may erode leakage protection for sales of both materials and manufactured products	Leakage risk fully avoided	Resource shuffling may erode leakage protection for sales of both materials and manufactured products

Business as usual: EU ETS with continued and declining free allocation

Free allocation provision has so far been successful in preventing carbon leakage for materials and manufactured products sold within the EU and abroad (Martin et al. 2014; Sato et al. 2015; Branger et al. 2016; Naegele and Zaklan 2019). Carbon leakage risks are fully addressed through free allowances and indirect cost compensation up to the benchmark level or the eligible share for indirect cost compensation. The difference between the average emissions intensity and the benchmark (based on the 10% best-performing installations), however, needs to be covered by the producers buying additional allowances.

Two already ongoing developments may reduce leakage protection. First, the increasingly ambitious GHG emissions reduction targets will require lower volumes of emission allowances and therefore higher prices in the EU ETS. Second, given the fixed share of allowances to be auctioned under Article 10(1) of the EU ETS Directive, the overall number of remaining allowances available for free allocation declines over time with the EU ETS cap. If the need for free allocation is not declining correspondingly, then a cross-sectoral reduction factor is applied to scale back free allocation to all installations. This means the price differential to countries without carbon pricing mechanisms will likely increase, since both the difference between average allowances needed by the producers and the EU ETS price are likely to increase in the future. There may also be investment leakage. In principle, increasing carbon prices make investments into more efficient or low-carbon processes more economically viable. However, the lower overall emission budget may make similar investments more attractive in countries without an equivalent carbon price. As explained in the previous section, a tightening of the emission budget inhibits large-scale conventional investment in the EU, since the emission budget available for conventional production decreases. At the same time, the lack of an effective and robust carbon pricing with a long-term perspective to cover incremental costs inhibits investment in climate-neutral production processes in the EU. As a result, particularly firms with global operations may prioritise investments in regions with clear investment perspectives.

Since there is neither carbon pricing for non-European products, nor an export rebate for European producers, resource shuffling is not a concern under free allocation.

Option 1a: CBAM on imports of basic materials with auctioning at a reference level

In this option, imports of basic materials from abroad face carbon costs similar to the costs of European producers. While this means that relative costs of European and non-European producers of basic materials are similar, the **primary materials may still be substituted with (potentially less carbon efficient) imports at the level of components or finished products**. Manufactured products produced and sold in the EU would face full carbon costs of the EU ETS, since these carbon costs would have to be paid irrespective of whether input materials are sourced domestically or imported. Manufactured products produced outside the EU, on the other hand, would not face such costs. In competitive sectors, EU production will thus be put at a disadvantage whenever the portion of inputs covered by the CBAM in the final product is significant for products that fall outside the scope of the CBAM.

Figure 3-1 shows that cost increases can be substantial even at a relatively moderate carbon price of 30 EUR/t for some product categories further down the value chain (panels C and D). These cost increases risk a substitution of EU products with potentially more carbon-intensive imports, if carbon costs cannot be passed on to consumers due to international competition on product prices.

The risk of cost increases further down the value chain can be partially mitigated by extending the scope of the CBAM. Deviating from the assumption that Options 1a and 1b include basic materials and basic material products only, a CBAM could include some PRODCOM categories of manufactured products that face a high carbon cost increase due to a high share of embedded materials. However, this is only possible to the extent that value chains for these goods are not integrated across borders, since otherwise these products would face carbon costs beyond consistent carbon pricing (more than single charging of the carbon content of goods). Alternative (more complex) MRV systems as discussed in Section 6, on the other hand, would be associated with much higher administrative burdens.

There would be **full exposure to incremental carbon costs with associated risks of carbon leakage for European exporters** under Option 1, since this form of CBAM has no impact on relative costs of EU and non-EU companies in external markets (Evans et al. 2020). Export adjustments have been found to play an important role in reducing carbon leakage (see the meta-analysis by Branger and Quirion 2014). Both European basic materials and manufactured products sold abroad would face full EU carbon costs but compete with products that probably do not bear such carbon costs. Consequently, EU exports would be likely to lose market share to non-European producers. This would result in a reduction of EU emissions at the expense of an increase of international carbon emissions. If the carbon intensity of the marginal international plant exceeds the carbon intensity of the EU marginal plant, this implies an overall increase of global emissions. In either case, the EU climate neutrality target would be reached at the expense of emission increases in other parts of the world.

The upstream basic material production alone that would be affected by increased costs for the share of production exported even at a moderate carbon price of 30 EUR/t is large, as shown above. The sectors with the highest share of production at risk from carbon leakage for exported materials under Options 1a and 1b are aluminium (almost half of the production is exported, cf. Table 3-3), pulp and paper (31 and 21 per cent export share, respectively) and steel (18 per cent exports). This risk for exporters could only be mitigated with the introduction of a reimbursement for exports (i.e. a move to Option 3), or a continued carbon leakage protection through free allocation of allowances (Option 4).

As in the reference case, there may be investment leakage, since a tightening of the emission budget inhibits conventional investment in EU. At the same time, the lack of a carbon pricing framework that reliably covers incremental costs inhibits investment in climate-neutral production processes in the EU. Resource shuffling would be fully avoided in this option, since importers are charged a carbon cost according to a default value that does not depend on actual emissions.

Option 1b: CBAM on imports of basic materials at the level of actual emissions

Carbon leakage risks due to the sale of basic materials or manufactured products within and outside of the EU, as well as incentives for investment leakage, are identical to Option 1a. However, unlike Option 1a, since importers would be allowed to challenge the default values of carbon intensity for basic materials with the actual carbon intensity, there are **full risks of resource shuffling** (See Box 1 in Section 3.3.1). Consequently, foreign producers may increase production with carbon-intensive products (at the margin) to realise profit potential by allocating clean energy sources or clean production processes to exports to the EU.

Option 2: CBAM on imports of carbon-intensive materials complementing free allocation

In Option 2, carbon leakage is avoided through a mixture of free allowance allocation (reference case) and the CBAM from Option 1. The effectiveness of avoiding carbon leakage depends on how much free allocation persists. If free allowance allocation is continued on a high level, this will result in greater carbon leakage protection, at the expense of lower incentives for investments in climate-neutral production, as well as reduced incentives for efficient material use and substitution.

As free allocation is phased out, three risks of carbon leakage increase: First, exporters face full carbon leakage risks at any level of the value chain. Second, for sales within Europe, those downstream parts of the value chain not covered by the CBAM are at risk of carbon leakage that are characterised by significant shares of carbon-intensive materials in their products, as well as a competitive environment (e.g. price-taking or only parts of increased carbon costs can be passed on to consumers). Third, resource shuffling may erode leakage protection for European producers even for products sold in Europe that are covered by the CBAM.

Option 3: CBAM on imports and exports of carbon-intensive materials including as part of products with full auctioning

In this option, leakage risk related to the sale of basic materials or manufactured products within and outside of the EU, as well as incentives for investment leakage, are fully avoided. Simulation studies and theoretical analyses have also found that a CBAM with export reimbursement such as Option 3 would be more effective in preventing carbon leakage than an import-only CBAM in preventing carbon leakage, since it prevents the loss of market share in external markets (e.g. Böhringer et al. 2012; Fischer and Fox 2012; Branger and Quirion 2014).

However, incentives for resource shuffling exist both for non-European and European producers. Foreign producers may increase production with carbon-intensive products (at the margin) to realise profit potential by allocating clean energy sources or clean production processes to exports to the EU. For European producers, resource shuffling incentives stem from the assumption to request that exporters track their incurred carbon costs, which are then refunded (up to a reference value). This would allow EU producers to attribute their less carbon efficient production to exports and thus largely avoid carbon price incentives for this share of production.

Option 4: Excise including CBAM on carbon-intensive materials including as part of products and continued free allocation

The excise duty combined with free allocation is the only option that fully avoids risks of carbon leakage. The excise is levied at the same level to domestic and internationally produced materials, irrespective of production processes. Hence it has no relevance for carbon leakage. In this option, leakage protection is provided not by the excise, but by continued free allocation (Ismer et al. 2016; Böhringer et al. 2017). The excise is, however, necessary for continued free allocation at the level of best available conventional technologies.

In the presence of an excise charge, the EU ETS cap may provide sufficient allowances to facilitate free allocation to conventional production processes at the level of best available conventional technologies, i.e. without application of the cross-sectoral correction factor currently foreseen by the EU ETS Directive[44]. If production volumes and emissions with conventional production technologies are at risk of exceeding the EU ETS cap, then the increasing allowance price and hence also the excise charge will trigger a demand reduction for carbon-intensive materials and thus also a reduction of their production and corresponding emissions. Increasing revenue from the excise charge also facilitate funding of additional climate-neutral production processes to substitute conventional processes. Thus, all mitigation options respond to the carbon price signal.

[44] Note that the discussion here is theoretical and does not aim to prejudice any reform of free allocation rules.

In contrast, in the BAU scenario, a cross-sectoral reduction factor is necessary and part of EU ETS to scale back free allowance allocation once it reaches a predetermined share of the EU ETS cap. A cross-sectoral reduction factor is necessary, because otherwise increasing allowance scarcity and allowance prices would only create incentives for production efficiency improvements. Material prices would not increase strongly enough and so there would be only limited incentives for adjustments of demand, production volumes and associated emissions. There would also be no strong business case for climate-neutral production. With such a limited responsiveness to carbon prices, their increases would have to be very high to balance demand and supply.

A cross-sectoral reduction factor does therefore exist and is required in the BAU scenario. It scales back free allocation and thus increases the carbon costs for basic material producers and through this channel contributes to a reduction of carbon-intensive production and emissions. However, as only European – but not international – producers face these incremental costs, part of the response to increasing carbon costs could involve the relocation of production and emission (carbon leakage).

With respect to resources shuffling, the excise does not create such incentives, neither for importers nor exporters. This is because the charge levied on carbon-intensive materials and manufactured products does not depend on the actual emissions of the production process.

Option 5: Carbon added tax including CBAM

Incentives for carbon leakage for the CAT are similar to those of Option 3, since both the tax levied on imports and the reimbursement for exports depend on the emissions actually incurred during the production process.

3.4.3 Secondary objective 1: International climate action

In this section, carbon price incentives related to imports from non-European producers and manufacturers are discussed. The criteria are analogous to the criteria set out under primary objective 1 for European firms. Moreover, support for global climate and trade cooperation, as well as the potential of the different options for policy diffusion with the perspective of global carbon pricing are discussed (Table 3-5).

Table 3-5: Summary of assessment of SO: International climate action

	Current ETS	Complementing measures to EU ETS					
	(BAU) Continued and declining free allocation	***(1a) CBAM on imports with auctioning (basic materials only) at a benchmark value***	***(1b) CBAM on imports with auctioning (basic materials only) at the level of actual emissions***	***(2) CBAM on imports complementing free allocation (basic materials only)***	***(3) CBAM on imports and exports with auctioning (materials also in finished products)***	***(4) Excise duty with CBAM and free allocation (materials also in finished products)***	***(5) Carbon added tax including CBAM (materials also in finished products)***
CO_2 price incentives for...							
Material producers (efficiency improvements) abroad		No incentive since CBAM is independent of actual emissions	Incentives for share that is exported to EU (if it outperforms default value)	Limited incentive in short term; incentives increase for share that is exported to EU with phase-out of free allocation	Incentives for share that is exported to EU (if it outperforms default value)	No incentive	Incentives for share that is exported to EU (if it outperforms default value)
Material producers (climate-neutral production) abroad	No incentive		Incentives for share that is exported to EU	Limited incentive in short term; incentives increase for share that is exported to EU with phase-out of free allocation			
Manufacturing and construction industry abroad			No incentive		Incentives for share that is exported to EU	Incentives for share that is exported to EU	Incentives for share that is exported to EU
Recycling abroad		No incentive since CBAM is independent of actual emissions	Incentives for share that is exported to EU	No incentive in short term; incentives for share that is exported to EU increase with phase-out of free allocation		No incentive	
Global cooperation and policy diffusion							
Support for global climate and trade cooperation	No concerns raised	Discriminates against clean foreign products, which are subject to higher burden than equivalent domestic products	Potential concerns about protectionism		Potential concerns about protectionism and extraterritorial tracing of carbon footprint	Potential use of excise revenue for targeted international climate action	Issues of extraterritorial tracing of carbon footprint
Example for policy diffusion with perspective of global carbon pricing	Lack of carbon price incentive for climate-neutral production, material use and recycling	Not compatible with multiple countries using system in parallel, since no refund for exports			Once sufficient countries participate to limit resource shuffling, attractive example and perspective	Attractive policy example and feasible pathway towards global carbon price	Once sufficient countries participate to limit resource shuffling, attractive example and perspective

Summary	Limited perspective as example to follow due to low-carbon price incentives for climate-neutral production, material use and recycling	Discrimination of foreign products may have adverse impact on climate and trade cooperation action; no incentives for non-European producers	Not compatible with multiple countries using system in parallel; no incentives for material efficiency and substitution	Not compatible with multiple countries using system in parallel; no direct incentives for non-European materials producers for material efficiency and substitution	Attractive, but only if enough countries implement it jointly	Attractive policy to implement sequentially or jointly, but limited direct incentives for non-European materials producers	Attractive, but only if enough countries implement it jointly

Business as usual: EU ETS with continued and declining free allocation

Under the current ETS, there are no incentives for non-European basic material producers, for the non-EU manufacturing and construction industry, or for non-EU recycling related to materials and manufactured products imported into the EU. There are also no major concerns raised with respect to global climate and trade cooperation.

The EU ETS has served as a blueprint for similar carbon pricing mechanisms around the world. However, there is a limited perspective for policy diffusion towards a global carbon price, since the current EU approach with free allocation does not offer a model how the carbon price incentive can be effective for climate-neutral production, material use and recycling (cf. BAU analysis in Section 3.4.1).

Option 1a: CBAM on imports of basic materials with auctioning at a reference level

Since the level of the CBAM is independent of actual emissions in this specification, there are no carbon price incentives for non-European material producers, for the manufacturing and construction industry, or for recycling related to materials and manufactured products imported into the EU.

The system would be controversial internationally, since it discriminates against clean foreign products, which could be subject to a higher burden than equivalent domestic products. The option also does not lend itself easily as an example for policy diffusion, since it is not compatible with multiple countries using a similar system in parallel: The absence of a refund for exports implies that when goods are traded several times between the EU and another country also implementing an import CBAM, these goods would be subject to the CBAM several times, increasing the burden of carbon costs beyond consistent carbon pricing.

Option 1b: CBAM on imports of basic materials at the level of actual emissions

Under this option, importers of basic materials would have the option to demonstrate that the carbon efficiency of their product is better than the default value. Consequently, this provides emission reduction incentives for the share of materials that is exported to the EU. Specifically, to the extent potential reductions of embedded emissions outperform the reference level, there are incentives for efficiency improvements for material producers abroad. The same is true for climate-neutral production and recycling of basic materials. However, due to the scope chosen for this option, all these incentives are limited to basic materials directly exported to the EU, not as part of products. There are no carbon price incentives for an increased efficiency and substitution in the manufacturing and construction industry abroad, since the CBAM in this model is levied on basic materials only, but not on manufactured goods.

In terms of supporting global climate and trade cooperation, Option 1b fares slightly better than Option 1a. As with Option 1a, the CBAM on imports with the option of paying the CBAM only according to actual emissions intensity is not compatible with multiple countries using carbon pricing systems in parallel, unless the MRV rules are set up accordingly, taking into account that for some emissions a carbon price was already paid. Section 5.2.5 presents formulae which could achieve this task, although at the expense of increased administrative complexity.

Option 2: CBAM on imports of carbon-intensive materials complementing free allocation

The incentives for international climate action in Option 2 is a mixture of the reference case and Option 1. For non-EU material producers exporting to the EU, there are limited incentives to increase production efficiency or invest in climate-neutral production as long as the CBAM covers only a small share of the EU reference carbon intensity. These incentives increase as the share of the CBAM increases. Recycling incentives outside of the EU also increase as free allocation is phased out (and replaced with the CBAM). As in Option 1b, there are no incentives for the manufacturing and construction industry abroad, since the CBAM is levied on basic materials only, but not on manufactured goods.

Regarding global cooperation and policy diffusion, Option 2 is also not compatible with multiple countries implementing the system in parallel due to the absence of an export reimbursement, as long as embedded emissions are not adjusted for carbon costs previously paid.

Option 3: CBAM on imports and exports of carbon-intensive materials including as part of products with full auctioning

Regarding the incentives for international producers and recycling, this option is similar to the CBAM on imports with the option to pay according to actual incurred carbon emissions (1b). However, due to the inclusion of the manufacturing value chain that uses significant amounts of carbon-intensive materials, there are also incentives for efficient and climate-neutral material production where it is embodied in products, or for material efficiency and substitution within manufacturing industries (for the share of products exported to the EU). These findings are, however, dependent on whether an MRV system can be established which provides reasonable data for products down the value chain, as otherwise the scope of this option would have to be limited as in Options 1 and 2.

Resource shuffling incentives could be effectively limited if enough countries implemented this option jointly, in addition to a harmonised carbon price. In such a case, the option could be implemented in several countries in parallel.

Option 4: Excise including CBAM on carbon-intensive materials including as part of products and continued free allocation

Since the excise duty relies on default values for the carbon intensity of basic materials, there are no incentives for efficiency improvements, climate-neutral production and recycling of basic materials produced abroad. This is the "price" that has to be paid for avoiding resource shuffling and limiting efforts for an extraterritorial tracing of incurred emissions. There are, however, incentives for the share of products exported to the EU from manufacturing and construction industries; since the excise is proportional to the weight of the materials imported, importers of manufactured goods may show that these goods contain less of the carbon-intensive materials than the reference value for a specific product.

Since the excise would generate considerably higher revenues at the EU level than the other forms of CBAM (see next section), part of this revenue may be used for targeted international climate action, which would support international acceptance of the measure. However, the Member States' auctioning revenues would be lower than under Options 1 to 3, which should be used for (international and domestic) climate action, too. Higher international climate spending would be justified because of the absence of direct incentives for less carbon-intensive production and recycling abroad. The excise duty could be implemented by several countries jointly to support a pathway towards a global single carbon price.

Option 5: Carbon added tax including a CBAM

Since the carbon added tax is levied on imports of both basic materials and manufactured goods according to the actual embedded emissions from upstream production (if producers to not want to resort to default values), incentives for non-European companies are similar to model 3 (CBAM on imports and exports).

In this option, there are concerns about the extraterritorial tracing of the carbon footprint for the CAT (see section on practical feasibility). As in Option 3, if enough countries implemented the CAT jointly (in addition to a harmonised carbon price), this would effectively limit resource shuffling incentives. The option could then be implemented in several countries in parallel.

3.4.4 Requirement 1: Practical feasibility

This section evaluates practical feasibility of the different CBAM options, measured by costs for setting up the system (including costs of an IT system for reporting), administrative effort for firms (EU and international) and governments, as well as compliance risks. Effort is discussed qualitatively in this section. A more specific assessment of compliance and enforcement costs will be made in the final report. Table 3-6 summarises the results.

Table 3-6: Summary of assessment of R 1: Practical feasibility

	Current ETS	Complementing measures to EU ETS					
	(BAU) Continued and declining free allocation	*(1a) CBAM on imports with auctioning (basic materials only) at a reference level*	*(1b) CBAM on imports with auctioning (basic materials only) at the level of actual emissions*	*(2) CBAM on imports complementing free allocation (basic materials only)*	*(3) CBAM on imports and exports with auctioning (materials also in finished products)*	*(4) Excise including CBAM and free allocation (materials also in finished products)*	*(5) Carbon added tax including CBAM (materials also in finished products)*
Costs for setting up the system	Already implemented	Determining default values for materials			Determining default values for materials and manufactured goods	Determining default values for materials and manufactured goods	Determining default values for materials and manufactured goods
Administrative effort for firms in the EU		Hardly any effort for producers of materials in the EU. Without free allocation less MRV effort than in BAU case			Some effort for European exporters in case of deviation from default values	Low effort for producers of materials in the EU; moderate effort for manufacturers along the value chain	Very high effort for all economic actors
Administrative effort for international firms		Low effort, since no deviation from default value	Moderate effort to attribute, trace and verify international emissions if below default value		High effort where importers deviate from default value in case of components or finished products	Low effort for importers due to reliance on default values	Very high effort where importers deviate from default value
Administrative effort for EU and national public administration			Medium verification efforts where deviation from default value		High verification efforts for tracing emissions related to imports and refund of exports	Low effort due to absence of verification efforts for carbon intensity of imported goods	Very high verification efforts for tracing carbon emissions related to imports and refund of exports
Compliance risks		Low risks, since no need for extraterritorial verification	Challenge: extraterritorial verification of carbon emissions of materials		Challenge: extraterritorial verification of embedded emissions, domestic attribution of carbon costs and cash refund	Low risks, since no need for extraterritorial verification	Challenges: extraterritorial verification of carbon emissions, domestic attribution of carbon costs and cash refund
Summary	Already implemented	Low administrative effort and compliance risks, since no deviation from default value	Moderate administrative effort when importers deviate from default value	Moderate administrative effort when importers deviate from default value	High administrative effort for tracing within EU and internationally	Overall low administrative effort, moderate along the value chain	Very high administrative effort due to extensive tracing requirements

Business as usual: EU ETS with continued and declining free allocation

There are no additional efforts beyond ongoing administrative efforts in the business as usual scenario.

Option 1a: CBAM on imports of basic materials with auctioning at a reference level

Regarding setup costs, the main challenge is determining default values for basic materials. In Section 5.2.5 there are two options defined for determining default values. Option MRV.Def.1 would use actual data collection from EU ETS operators in a similar way, as EU ETS benchmarks are currently defined. This would be highly burdensome. Alternatively, option MRV.Def.2 would use literature and expert judgement to come up with these values, which would be at very low administrative levels, but at the cost of possibly more challengeable values. There is some preference for the latter option. Hence, administrative effort for European firms would be low, since there would be no additional administrative obligations. Since importers cannot deviate from default values in this option, the administrative effort is low also for international firms. The same holds true for EU governments, since there is no need to verify deviations from the default values. Due to the absence of extraterritorial verification, compliance risk is also low.

Option 1b: CBAM on imports of basic materials at the level of actual emissions

As in Option 1a, default values for basic materials present the main challenge regarding setup costs. Administrative efforts for EU companies are low under the preferred approach to determine these values. Administrative effort increases for attributing, tracing and verifying international emissions if importers of basic materials deviate from the default value, both for international firms and for EU governments. Moreover, the extraterritorial verification of carbon emissions is also a challenge for compliance. More detail is given in Chapter 5, where a multitude of design options are given for how such a CBAM could work in practice. For some of these options, administrative costs are estimated in Section 5.9.

Option 2: CBAM on imports of carbon-intensive materials complementing free allocation

Administrative effort is similar to Option 1b. However, there are additional administrative costs for continuing to determine the level of free allocation that producers should receive, such that the combined administrative effort is higher than in either BAU or Option 1 alone.

Option 3: CBAM on imports and exports of carbon-intensive materials including as part of products with full auctioning

Default values have to be determined both for materials and manufactured goods in this option, making this element more costly than for Options 1 and 2. There is some (limited) additional effort for European exporters in case of a deviation from default values of embedded emissions, since such deviations would have to be traced along the value chain their determination for manufactured goods. In case of imports, a similarly high effort is necessary as under Options 1b and 2. EU governments will face additional verification efforts for tracing carbon emissions related to the refund of exports, as well as for verifying international emissions if importers deviate from the default value as under Options 1b and 2. In addition to the extraterritorial verification of carbon emissions, challenges related to compliance risks include the domestic attribution of carbon costs and the cash refund to exporters, which increases risks of fraud, especially down the value chain (Ismer et al. 2016).

Option 4: Excise including a CBAM on carbon-intensive materials including as part of products and continued free allocation

As in Option 3, default values have to be determined both for materials and manufactured goods. Administrative effort is low for producers of materials in the EU, since the excise relies on default values for basic materials, which means producers do not have to demonstrate the carbon intensity of their production. Manufacturers along the value chain would have some additional effort, since the use of duty suspension arrangements would require them to report the weight of basic materials upon the sale of their products, as well as submit periodic returns to the relevant national authorities (Ismer et al. 2016). However, where increased administrative costs outweigh the carbon costs of materials in products, manufacturers would also have the option to pay the excise rather than register under the duty suspension regime.

Administrative costs for international firms are relatively low, since importers would be charged according to the weight of the material imported, without having to demonstrate the carbon intensity of the production process. For the same reason, no verification efforts for the carbon intensity of imported goods are need for EU governments. Compliance risks are also low due to the absence of a need for extraterritorial verification.

Option 5: Carbon added tax including a CBAM

As in Options 3 and 4, default values for materials and manufactured goods would have to be determined. These could be used as a fallback option for importers of materials and manufactured goods who do not want to demonstrate the carbon intensity of their products.

Due to the extensive tracing and reporting requirements described in Section 5.2 administrative effort would be very high for all firms along the value chain, both in Europe and internationally, to such an extent that this option appears unrealistic. The additional objective of covering emissions not only from basic material production but also from subsequent production processes further increases the complexity of MRV requirements (not only, but in particular if importers decide to deviate from the reference values[45]). As a result, efforts for governments related to an extraterritorial verification of carbon emissions, domestic attribution of carbon costs and cash refund would also be very significant. In addition, the carbon added tax would be applied to consumer products, such as household appliances, clothes, cars, computers, etc. The sheer multitude of products potentially subject to a CAT, their complex and frequently changing value chains, and hence the great number of actors involved in the relevant data collection, make it unlikely that the data would be very reliable. Data would only be robust enough if there were a strong legal basis and compliance control in all the countries of origin of the raw materials and intermediate products needed to manufacture the said products.

3.4.5 Revenue generation

Stede et al. (2021) provide preliminary calculations on the potential additional annual revenues under different CBAM options (Options 1-4) for the materials steel, aluminium, plastics, paper, cement. Calculations are based on 2019 trade flow data, assuming a CO_2 price of 30 EUR/t. For the analysis of Options 1 and 2, it was assumed that import charges cover basic materials and basic material products. The analysis for options 3 and 4 considers also the trade of components and final goods.

[45] For example: if a car manufacturer in the EU imports a combustion engine from outside the EU in order to build a car, the embedded emissions of the engine need to be monitored/tracked outside the EU. This may contain parts of steel, aluminium, magnesium, special ceramics etc. Even if only the default values for the embedded emissions of these materials are used, it would need some monitoring along the value chain.

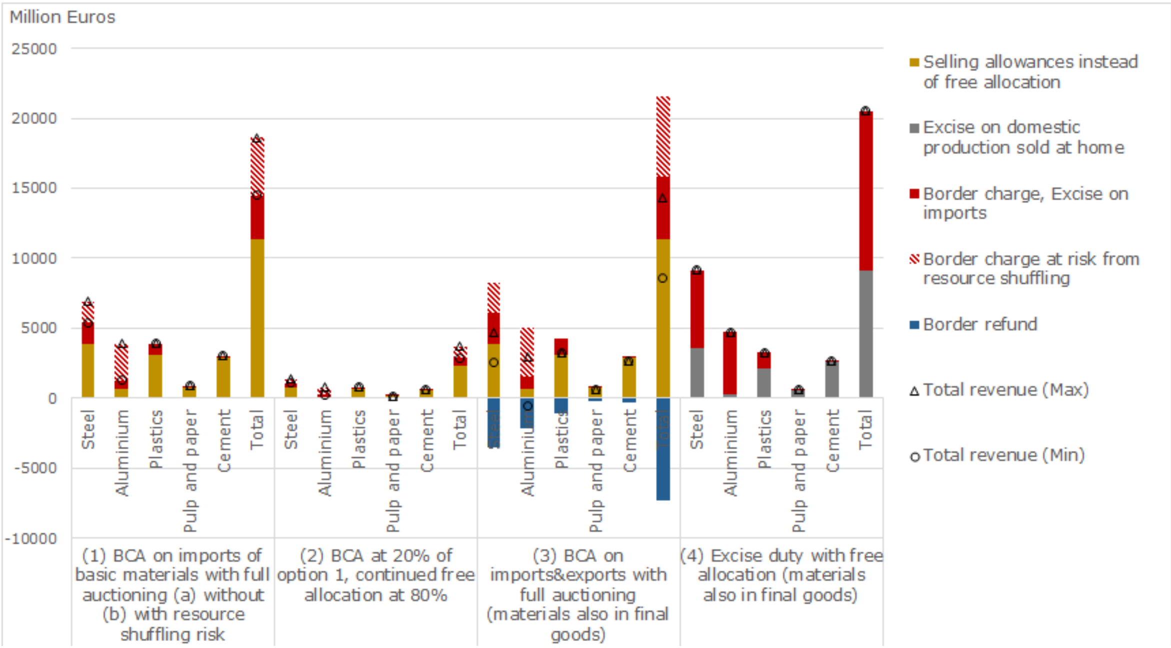


Figure 3-2: Comparison of expected fiscal revenues of options 1 to 4 compared to the business as usual case.

Notes: Assumed reference values (t CO_2-eq/t material) are 1.78 for steel (1.4 for a share of 20% scrap in primary (BOF) steelmaking), 12.82 for aluminium, 1.5 for plastics, 0.09 for pulp, 0.308 for paper, and 0.69 for cement (see p.8ff in Pauliuk et al. 2016 and Stede et al. 2021). The calculation assumes that the actual carbon intensity of imports in Options 1-3 is based on these reference values. For Options 3 and 4, all PRODCOM categories of components and final products that contain one of the five basic materials, i.e. steel, aluminium, plastics, pulp and paper, or cement are assumed to be covered by the CBAM or excise. In the calculation of additional auction revenues for steel in Options 1-3, we assume a share of 20 per cent scrap in blast oxygen furnaces, for which no additional auctioning revenue is raised. Revenues under Option 1-3 do not include additional revenues from a phase-out of power price compensation at the level of the Member States. Half of the revenues from imports of basic materials and basic material products are assumed to be at risk from resource shuffling for steel, as well as 80% of aluminium revenues in these product categories. Components and final products are assumed to be exempt from resource shuffling. The static analysis does not consider more efficient material use in response to carbon pricing or changes of volumes of trade flows due to resource shuffling

The analysis assumes constant trade flows, as well as no changes in production and consumption patterns. Production volumes, as well as figures on imports and exports of basic materials and basic material products underlying the calculations are available from Table 3-3. The predicted revenues should thus be seen as potential revenues. For all CBAM and alternative measures, the revenue would decline if climate policies or climate action of third countries was credited at the border.

Table 3-7 gives an overview of the results.

Table 3-7: Summary of assessment of annual revenue generation

	Current ETS	Complementing measures to EU ETS					
	(BAU) Continued and declining free allocation	***(1a) CBAM on imports with auctioning (basic materials only) at a reference level***	***(1b) CBAM on imports with auctioning (basic materials only) at the level of actual emissions***	***(2) CBAM on imports complementing free allocation (basic materials only)***	***(3) CBAM on imports and exports with auctioning (materials also in finished products)***	***(4) Excise including CBAM and free allocation (materials also in finished products)***	***(5) Carbon added tax including CBAM (materials also in finished products)***
Revenue estimate*	0 in the short term, some additional ETS auction revenue as cap decreases	7.2 billion euro for CBAM, additional ETS auction revenue 11.4 billion euro	3.1 to 7.2 billion euro for CBAM (depending on level of resource shuffling), additional ETS auction revenue 11.4 billion euro	0.6 to 1.4 billion euro for CBAM (depending on level of resource shuffling), additional ETS auction revenue 2.3 billion euros**	–2-8 to +3 billion euro from CBAM (depending on level of resource shuffling), additional ETS auction revenue 11.4 billion euro	20.5 billion euro excise revenue (9.1 billion levied on materials produced in EU, 11.4 billion on imported materials included also in products)	Similar to CBAM on imports and exports
Revenue risk	Incremental costs for climate-neutral technologies to be covered through public budgets	Would decline if policy / climate action of third countries is credited	Would decline if policy / climate action of third countries is credited	Would decline if policy / climate action of third countries is credited	Would decline if policy / climate action of third countries is credited	Partial use for international climate action	Would decline if policy / climate action of third countries is credited
Summary	0 in the short term, some additional ETS auction revenue as cap decreases	7.2 billion euro for CBAM, additional ETS auction revenue 11.4 billion euros***	3.1 to 7.2 billion euro for CBAM (depending on level of resource shuffling), additional ETS auction revenue 11.4 billion euros***	0.6 to 1.4 billion euro for CBAM (depending on level of resource shuffling), additional ETS auction revenue 2.3 billion euro ***	–2.8 to +3 billion euro from CBAM (depending on level of resource shuffling), additional ETS auction revenue 11.4 billion euros***	20.5 billion euro excise revenue (9.1 billion levied on materials produced in EU, 11.4 billion on imported materials included also in manufactured products)	Similar to CBAM on imports and exports

* Preliminary estimate using 2019 trade flow data. Assumptions: materials covered are steel, aluminium, plastics, paper, cement; CO_2 price of 30 EUR/t.

** Assuming a coverage of 80% of the EU ETS benchmark through free allocation, and 20% through CBAM.

*** Auction revenue will decline to the extent that resource shuffling opportunities increase imports and reduce domestic production, emissions and allowance prices.

Business as usual: EU ETS with continued and declining free allocation

In the short term, there would be no additional revenue in this option. As the EU ETS cap decreases and EU ETS allowances prices increase, there would be some additional revenue (see revenue estimate for Option 1 in Figure 3-2 for a potential scale of revenues under full auctioning). There is some revenue risk, since the incremental costs for climate-neutral technologies have to be covered through public budgets in this option.

Option 1a: CBAM on imports of basic materials with auctioning at a reference level

Additional revenue would be 7.2 billion euro for CBAM (i.e. at the border), as well as an additional ETS auction revenue of 11.4 billion euro. The largest part of the CBAM revenue comes from steel, plastics and aluminium. There is almost no additional revenue from cement at the border, due to very limited trade flows (Figure 3-2).

Option 1b: CBAM on imports of basic materials at the level of actual emissions

Of the 7.2 billion euro of CBAM revenue, a large fraction is at risk due to potential resource shuffling in the aluminium and steel sectors. In an extreme scenario where half of the steel revenues and 80 per cent of the aluminium revenues are foregone due to resource shuffling, the total CBAM revenue might decline to 3.1 billion euro.

Option 2: CBAM on imports of carbon-intensive materials complementing free allocation

Under a CBAM combined with free allocation, additional revenues would be lowest. Depending on the level of resource shuffling, it would be between 0.6 to 1.4 billion euro for the CBAM. Additional ETS auction revenue is 2.3 billion euro (assuming free allocation is reduced by 20 per cent and these 20 per cent are covered by an import-only CBAM). For the estimation it is assumed that the CBAM would cover 20 per cent of the materials reference value, while the remaining 80 per cent would continue to receive free allowances calculated at benchmark level.

Option 3: CBAM on imports and exports of carbon-intensive materials including as part of products with full auctioning

Relative to the previous options, Option 3 has increased revenues due to more (manufactured) products being covered by the instrument. On the other hand, revenues are lower due to the rebate given to exports, which decreases EU revenues from the CBAM. The net effect is negative: Total revenues would be between –2.8 and +3 billion euro, depending on the level of resource shuffling[46]. The maximum level of revenues (without resource shuffling) would be 14.3 billion euro. This option could therefore potentially turn into a net liability at the EU level due to a combination of the export rebate and potential resource shuffling.

Option 4: Excise including a CBAM on carbon-intensive materials including as part of products and continued free allocation

The excise duty generates the highest revenues, a total of 20.5 billion euro. The majority of the revenue (11.4 billion) can be attributed to materials that were imported at some stage of the value chain, but a large share (9.1 billion) is generated by the duty charged on domestically produced materials. In contrast to the previous options, where a large share of the revenues is

[46] For aluminium, the risk of resource shuffling is assumed to be present only at the level of primary manufacturing, but no resource shuffling risk is assumed for component or articles of materials and final goods. This limits the share of the total revenues subject to resource shuffling risks.

from free allocation and thus accrues to the Member States, all revenues from the excise are at the EU level.

There is no risk of resource shuffling to the revenues, since the excise relies on default values for the imports of products. Whereas in Options 1b and 2, international producers receive incentives to pursue low-carbon material production, this is not the case in Option 4. Hence there is a stronger political case to also dedicate a part of the revenue to support international climate action.

Option 5: Carbon added tax including a CBAM

Potential revenues from the CAT are higher than Option 3 due to the inclusion of additional emissions in later stages of the production process. However, no quantification of this scale has been made by Stede et al. (2021).

3.5 Conclusion: identification of feasible options

Section 3.4 has shown that there is clearly a case for complementing the EU ETS with a CBAM or alternative measure. There are two main reasons for this. First, the carbon price is currently not fully consistent due to free allowance allocation. This results in strongly reduced carbon price incentives for material efficiency, recycling, and clean processes. Second, although free allocation might be sufficient to mitigate carbon leakage risk in the short term, a declining ETS cap in the context of increasing EU climate ambition will erode carbon leakage protection in the medium term.

Table 3-8 summarises the assessment of the options of the previous section.

Table 3-8: Summary of assessment of impacts

	Current ETS	Complementing measures to EU ETS					
	(BAU) Continued and declining free allocation	***(1a) CBAM on imports with auctioning (basic materials only) at a reference level***	***(1b) CBAM on imports with auctioning (basic materials only) at the level of actual emissions***	***(2) CBAM on imports complementing free allocation (basic materials only)***	***(3) CBAM on imports and exports with auctioning (materials also in finished products)***	***(4) Excise including CBAM and free allocation (materials also in finished products)***	***(5) Carbon added tax including CBAM (materials also in finished products)***
Primary Objectives							
PO1: Support the EU's transition to climate neutrality	Largely inconsistent carbon pricing incentives for material efficiency, recycling (cement, plastic), and clean processes	Reduced carbon price incentives for material efficiency and clean processes		Carbon pricing incentives for material efficiency, recycling, and clean processes only created as free allocation is phased out	Full carbon price incentives for domestically sold products, limited incentives for exports	Full carbon price incentives for efficient/ clean material production and recycling, no downstream incentive for efficient material use in exports	Full carbon price incentives for domestically sold products, limited incentives for exports
PO2: Avoid carbon leakage risk	Avoided but could result from tightening ETS cap; lack of perspective could trigger relocation of investment	Resource shuffling risks avoided; however, significant risk along value chain and in export markets	Resource shuffling may erode leakage protection; significant risk along value chain and in export markets	Short-term leakage risk avoided; however, inconsistent investment framework could trigger relocation of investment	Resource shuffling may erode leakage protection for sales of both materials and manufactured products	Leakage risk fully avoided	Resource shuffling may erode leakage protection for sales of both materials and manufactured products
Secondary Objectives							
SO1: International climate action	Limited perspective as example to follow due to low-carbon price incentives for climate-neutral production, material use and recycling	Discrimination of foreign products may have adverse impact on climate and trade cooperation action; no incentives for non-European producers	Not compatible with multiple countries using system in parallel; no direct incentives for non-European producers for material efficiency and substitution	Not compatible with multiple countries using system in parallel; no direct incentives for non-European materials producers for material efficiency and substitution	Attractive, but only if enough countries implement it jointly	Attractive policy to implement sequentially or jointly, but limited direct incentives for non-European materials producers	Attractive, but only if enough countries implement it jointly
Requirements							
R1: Practical feasibility	Already implemented	Low administrative effort and compliance risks, since no deviation from default value	Moderate administrative effort when importers deviate from default value	Moderate administrative effort when importers deviate from default value	High administrative effort for tracing within EU and internationally	Overall low administrative effort, moderate for value chain	High administrative effort due to extensive tracing requirements

Options 1a and 1b fare better than the BAU scenario in terms carbon price incentives due to the move to full auctioning. However, the competition from imports of components and finished products weakens the ability to pass through costs along the value chain. Option 1a eliminates resource shuffling risks by not allowing importers to deviate from default values (reference values). Imports are thus burdened independently of the actual production processes. Option 1b, on the other hand, allows importers of basic materials to demonstrate that their individual production process is more efficient than the reference value. This, however, opens the door to resource shuffling concerns in sectors like aluminium, steel and plastics, which was also confirmed by concerns voiced in the stakeholder consultation (see Appendix 2: Stakeholder consultation results).

Both Options 1a and 1b have the major disadvantage that downstream producers are not protected by the CBAM, which might lead to carbon leakage. Importers of competing foreign products would not face the same carbon costs as European producers and thus enjoy a competitive advantage. This could be mitigated to some extent by including product groups with high relative cost increases due to a consistent carbon pricing, but only insofar as value chains of the production processes are not integrated across borders, since the carbon content of the products would then be charged more than once.

European exporters are subject to full leakage risks in Option 1 along the value chain, since they would face competitive pressure from foreign producers whose products are not subject to equivalent carbon costs. As the analysis in Section 3.4.2 has shown, a large number of industries would be affected by high relative cost increases even under a relatively moderate carbon price. Moreover, a significant share of basic materials and basic material products is exported in most sectors. Consequently, in the stakeholder consultation industrial stakeholders from all economic sectors raised major concern about the lack of coverage for exporters. The carbon leakage risk for exporters cannot be mitigated under Option 1.

Option 2 would require a credible commitment to a limited transition period, since it keeps the disadvantages of free allocation, without reaping the full benefits of a well-designed CBAM. While it might be viewed as a short-term solution to carbon leakage risks by continuing free allowance allocation, the disadvantages of Option 1 will resurface as soon as free allocation is phased out, since Option 2 then converges to Option 1b. Moreover, it does not provide the consistent carbon pricing signals needed for investments in climate-neutral production processes. Similar as with Option 1, it may work in the short term for the cement sector, since that sector is characterised both by comparatively low exports of basic materials and a lack of manufactured products traded globally. However, it is not a model for other important sectors such as steel. Moreover, both Options 1 and 2 are not compatible with multiple countries using the system in parallel due to the lack of an export reimbursement.

Option 3 combines full carbon price incentives for carbon-intensive materials and manufactured goods sold domestically with, in principle, sound carbon leakage protection. However, importers are allowed to deviate from the reference values, which implies there are incentives for resource shuffling that could erode leakage protection. The main concern relates to the refund of incurred carbon costs for exports. This implies that carbon-intensive European production will be dedicated to exports and then lacks an incentive to improve performance. This undermines the intended and perceived environmental objective especially of the export rebate. Moreover, concerns about administrative complexity have arisen in the stakeholder consultation in case of a wide product coverage along the value chain. Consequently, coverage of products along the value chain could therefore be limited to the sectors where a full carbon cost pass-through would induce significant production cost changes (see Figure 3-1-).

Finally, depending on the level of resource shuffling, fiscal revenues for the CBAM might become negative due to the export rebate.

Option 4 (excise duty) is an option that performs well in our initial assessment across the various objectives and criteria, on consistent carbon pricing and avoiding carbon leakage risks, as well as resource shuffling. The excise is levied independently of origin and of production methods, and is seen as practically feasible by many stakeholders, while raising significant revenue. It does not create incentives for international producers for a less carbon-intensive production. This is the flip side of the coin for avoiding both resource shuffling incentives and extraterritorial tracing and verification. Stakeholders regarded the excise as providing an attractive investment framework for climate-neutral production processes.

Although its potentially wide scope may seem attractive, **Option 5** (carbon added tax) appears less practical because of the very extensive domestic and international tracing, attribution and verification requirements, implying significant administrative efforts for all parties involved. This was confirmed by the stakeholder consultation. Otherwise, the option has full carbon incentives for domestic production, but similarly to Option 3 resource shuffling is a concern domestically and internationally. Resource shuffling may also undermine the environmental credibility of the refund of incurred carbon costs, which could result in a continued operation of European carbon-intensive assets for the purpose of exports.

4. KEY ELEMENTS FOR DEFINING THE SCOPE OF THE CBAM

This chapter describes the issue of scope independently of the main design options discussed in Chapter 3, and builds on the options defined for detailed implementation approaches of the CBAM, such as the definition of "embedded emissions" and the related MRV provisions, which are crucial for defining the scope of the CBAM, as will be explained in this chapter. Those definitions and options are discussed in Chapter 5, and a summary of the options and conclusions on the options in this regard are given in Section 5.5.

4.1 Overview

Several principal aspects have to be discussed regarding the feasible scope for a carbon border adjustment mechanism:

(A) The industry sectors affected, using a suitable classification such as NACE (see Section 4.3);

(B) How far down the value chain the CBAM should be applied (whether only basic materials or more complex products should be covered, see Section 4.4, and which elements to take into account to define their relevant embedded emissions). Such a discussion should lead to a list of materials and products which are identifiable in terms of product codes used in international trade, such as the CN[47] system;

(C) The geographical scope (Section 5.7); and

(D) The temporal dimension (Section 4.7).

All of these aspects are discussed in the report, although the focus is on points (A) and (B). As the discussion on the technical design elements in Chapter 5 shows, aspect (B) has strong links to the necessary carbon content definition (more appropriately termed "*embedded emissions*") which needs to be aligned with emissions also covered by the EU ETS (or would be covered, if those emissions happened in the EU). They may take the form of a "specific partial product carbon footprint" (see Section 5.2.2). Options to define embedded emissions have an inevitable link to the necessary *MRVA system*, which in turn have strong impacts on the technical and administrative *feasibility* of the CBAM (see summary of options in Section 5.5). Aspect (B) therefore has to be assessed in close connection with those design elements. Section 4.4 will specifically discuss the impact of practical feasibility aspects on the selection of sectors/products.

Figure 4-1 presents the proposed process of determining the scope of the CBAM, and indicates the sections of this report in which the different steps are discussed. **Note that the present Chapter 4 deals only with materials and products. For the potential inclusion of the power sector (i.e. electricity production) please see Chapter 6.**

[47] Combined Nomenclature

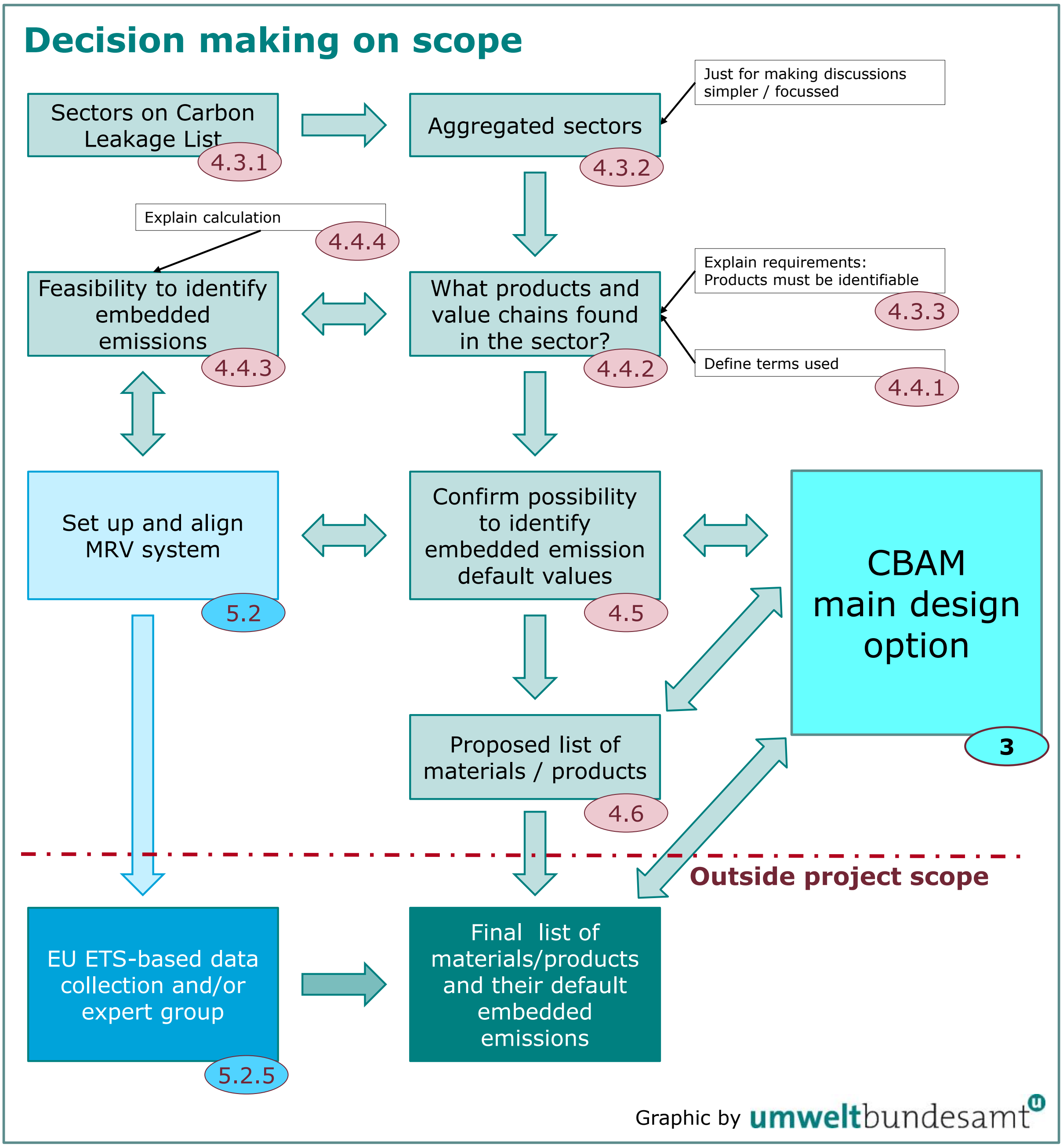


Figure 4-1: Overview of the decision-making process for determining the scope of the CBAM. The numbers refer to the chapters of this report where those steps are discussed.

4.2 Assessment criteria for the sectoral scope of a CBAM

The purpose of a CBAM is to provide similar conditions between producers within the EU and abroad specifically in respect of any costs for GHG emissions caused by their production. These costs are generated in the EU by its emission trading system (the EU ETS). This assumption requires that the further discussion in this chapter focuses on those emissions affected by the EU ETS. Therefore, other emissions, such as e.g. from upstream operations (mining, transport, etc.) are considered not relevant (see Section 5.2.2). For the same reason, other aspects contributing to different competitive (dis-)advantages, such as possible carbon or energy taxes, subsidies for diverse energy carriers etc. are not within the scope of this study.

For defining whether an industry sector should be covered by the CBAM, the following criteria are used:

- **Relevance in terms of emissions** (i.e. whether the sector is a significant emitter of greenhouse gases, and whether there is an emission reduction potential), which for the purpose of this study and in line with the EU ETS' design[48] can mean the following sub-cases:
  - Relevance regarding ***direct emissions***: We translate this into "are there installations in the sector covered by the EU ETS?". This means that if a sector's structure is such that installations are typically too small to be covered by the EU ETS, the sector does not face emission costs and is by definition not exposed to carbon leakage. Hence, we exclude sectors without EU ETS installations from the analysis with the exception mentioned under the next point.
  - Relevance regarding ***indirect emissions***[49]: This sub-criterion would identify sectors in which carbon leakage risk is induced by the increase of electricity prices due to the carbon costs borne by the producers of electricity from fossil sources. No EU-wide list of installations falling within this category is available, as few[50] Member States apply the indirect cost compensation. Therefore, as an indicator to decide if a sector should be covered by this criterion, we ask whether the EU State Aid Guidelines for indirect EU ETS cost compensation[51] have identified the sector as eligible based on the "indirect carbon leakage indicator". For practical reasons it is also of interest whether those guidelines contain a benchmark for products of this sector.
- **Exposure to a significant risk of carbon leakage** (as defined pursuant to the EU ETS Directive);
- Applying these first two criteria gives a list of sectors which produce energy-intensive and trade-exposed materials and products. These range from (mixtures of) chemical substances such as ammonia, ethylene glycol, cement clinker over commodities of certain specifications (e.g. PRODCOM 24.20.21.10 "*Line pipe, of a kind used for oil or gas pipelines, longitudinally welded, of an external diameter > 406,4 mm, of steel*", or PRODCOM 23.13.11.50 "*Bottles of coloured glass of a nominal capacity < 2.5 litres, for beverages and foodstuffs (excluding bottles covered with leather or composition leather, infant's feeding bottles)*") to final products[52] which may be immediately sold to consumers (e.g. gasoline and diesel, certain fertilisers, ceramics products (tiles, tableware), some (table) glass ware, etc.). Some of these "consumer products" would have to be classified "basic material products" using the definitions in Section 4.4.1. Therefore, it is difficult to define a uniform criterion regarding the **depth of the value chain** that can or should be covered by a CBAM. Nevertheless, Sections 4.4.2 to 4.4.4 approach this topic. The value

[48] Note that other classifications of emissions exist, such as the scope 1, 2 and 3 of the "GHG protocol" by the WBCSD (https://ghgprotocol.org/), but due to the necessity to compare to the EU ETS, these classifications are not suitable.

[49] In this report we use the term "indirect emissions" for emissions from electricity production, unless otherwise stated. Emissions from e.g. heat and steam production – even if carried out in a separate installation – are considered as direct (EU ETS) emissions, because the free allocation rules (Commission Delegated Regulation (EU) 2019/3319 ensure that consumers of the heat receive free allocation, and the CL risk is therefore mitigated in the same way as for other direct emissions.

[50] According to the Commission's recent evaluation (SWD(2020) 194), 12 MS and Norway provide compensation pursuant to Article 10a(6) of the EU ETS Directive.

[51] These guidelines have been recently amended for the purpose of the 4th EU ETS trading period, see https://ec.europa.eu/competition/state_aid/what_is_new/news.html. However, Commission Communication C(2020) 6400 final does not yet contain any new benchmarks. Therefore, we use the relevant 3rd phase benchmarks given by Commission Communication 2012/C 387/06.

[52] Note that here we do not use the definitions proposed in Section 4.4.1 in order to demonstrate the difficulty of classification. What one sector considers a final product may be just the starting point for the next manufacturer in the value chain.

chain issue is also firmly linked to the options chosen for defining embedded emissions and impact the administrative burden via the MRV system required (see Section 5.2).

- **Practical arguments** need to be taken into consideration:
  - **Whether a material or product class can be clearly defined**, and whether materials or products can be **unambiguously identified in practice** when the level of CBAM obligation needs to be determined;
  - Ultimately, the conclusions on a proposed CBAM scope in Section 4.6 are drawn from our judgement **that it will be feasible to define reference values for the embedded emissions** as the decisive argument for the inclusion a product or a material in the CBAM. Without such reference values it is impossible to calculate the CBAM obligation to be paid upon import. Section 5.2.5 provides two different approaches to how those values can be determined.
  - Furthermore, the choice of the scope will require certain design choices on other elements (e.g. it is pointless to require the inclusion of more downstream products in the scope, if MRV rules and the definition of embedded emissions do not take into account more upstream emissions). Section 5.2.3 discusses the **design choices for embedded emissions**. However, availability of data for defining reference values on embedded emissions need to be balanced against the desire to limit administrative burden, which may impact on the scope that can be covered by the CBAM. Section 5.2.5 provides two options on how the default values can be determined, which show that – if not too many steps in the value chain are considered – the definition of default values should be possible, at least for the basic materials and basic material products listed in the section on scope conclusions (4.6).
- The range of the CBAM's scope has an impact on the **revenues raised** by the CBAM itself (as the EU's own resources) as well as on Member States' EU ETS auctioning revenues, when free allocation is ended (or phased out) as consequence of the CBAM's introduction. Revenues raised under certain assumptions are compared for the different main options of the CBAM design in Section 3.4.5) However, when selecting sectors, we do not consider the revenues as a primary criterion in this report. They would be a secondary objective of the design, not a driver of the design. We will therefore not use it as a criterion in the analysis here. Furthermore, revenues are also very strongly influenced by whether indirect emissions and elements of the value chain are taken into account for embedded emissions (see summary of options in Section 5.5). It would therefore not be appropriate to assess this topic in isolation based only on the materials and products in the CBAM's scope.

4.3 Starting point: industry sectors

4.3.1 Industrial sectors at risk of carbon leakage

The starting point is that the CBAM is intended as an instrument to establish a comparable carbon price on goods produced in or imported to the EU with the objectives of creating consistent incentives for emissions reduction, to limit the risk of carbon leakage (CL) from the EU ETS, and to incentivise the use of carbon pricing as a policy measure to mitigate GHG emissions in other parts of the world. Consequently, the CBAM should focus on those sectors that have already been identified as being at risk of carbon leakage. The applicable criteria for defining the CL risk are laid down in Article 10b of the EU ETS Directive. The list of sectors adopted by the Commission based on these criteria is given in Commission Delegated Decision (EU) 2019/708 (referred to as "the CL

List" or "CLL" hereafter). The CLL contains 50 sectors at 4-digit NACE level and a further 13 sectors at more disaggregated level (6- or 8-digit PRODCOM).

To successfully implement a CBAM, those 63 sectors and the multitude of products and materials produced by them might be too difficult to regulate. It is proposed to focus on fewer sectors, at least for a pilot phase. This would make the CBAM simpler and more manageable. Figure 4-2 shows NACE sectors against these CL criteria. It is evident that only few sectors contribute with *significant emissions* and are therefore at CL risk due to their emission costs, while many sectors are on the list merely due to their *trade intensity*. The CBAM should focus on those few sectors with significant emissions and where a CBAM can provide the highest environmental impact with relatively low administrative effort. In particular, this would make it possible to focus on the carbon-intensive basic materials at the core of each of these sectors' activities (like cement clinker, steel, organic chemicals, etc.). This approach is often found in the literature.

Moreover, the discussion of MRV systems and the possibilities to define the "embedded emissions" of products (see Section 5.2) demonstrates that implementation of the CBAM becomes the more difficult the more significant manufacturing steps are included after those which are directly included in the EU ETS. This is another argument that justifies the focus on industry sectors and products under the EU ETS.

However, for the purpose of this report it is important not to jump to conclusions too quickly. On the contrary, the wide set of design options presented in Chapter 3.2 considers that theoretically *all* products placed on the European market might be subject to a carbon price based on their partial carbon footprint. Therefore, the analysis here starts from the assumption that all kinds of goods could be theoretically included in a CBAM.

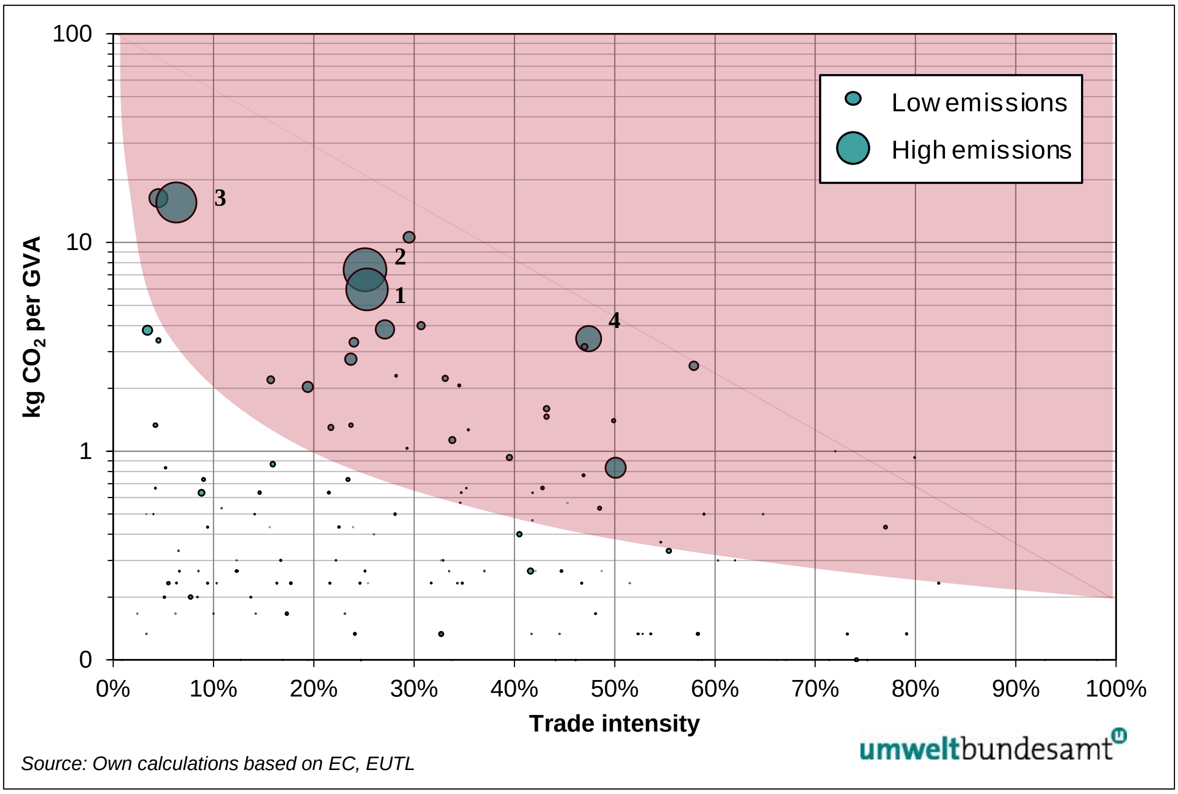


Figure 4-2: Position of NACE sectors regarding the CL criteria for the fourth EU ETS phase.

Note: Sectors in the coloured area are considered to be exposed to a risk of carbon leakage in line with the EU ETS Directive (Article 10b). The sectors with the highest emissions in this picture are: (1) Iron and steel, (2) Refining of mineral oil, (3) Cement; (4) Organic basic chemicals.

4.3.2 Proposed aggregated sectors for further discussion

The CLL contains 50 sectors at 4-digit NACE level and a further 13 sectors at more disaggregated level (6- or 8-digit PRODCOM). To facilitate the discussion of these sectors, we have aggregated several NACE codes into fewer, more aggregated "sectors" and assigned shorter sector names. For this purpose, we have considered only NACE codes which are found on the carbon leakage list (CLL[53]) for the fourth phase of the EU ETS *and* for which installations are currently found in the EU ETS[54]. This aggregation is given in Appendix 3: Supplementing tables for Chapter 5 on the sectoral scope of the CBAM (Table A-3), sorted by direct emissions of the aggregated sector. The table furthermore presents the number of installations in these sectors in the EU ETS, their emissions, and the number of affected PRODCOM codes as an indicator for the potential complexity of the sector.

Furthermore, Table A-3 (Appendix 3: Supplementing tables for Chapter 5 on the sectoral scope of the CBAM), shows which EU ETS product benchmarks can be found in each of the proposed aggregated sectors as an indicator for the possible complexity of the sector (note that in some cases product benchmarks apply separately for separate products of the sector, e.g. either grey or white cement clinker), while in other cases a (sometimes complex) value chain is found (e.g. for a polymer: refinery → steam cracker + chlorine → VCM → S-PVC; or in the fertiliser sector: Ammonia → nitric acid or urea → various NPK fertilisers). Furthermore, we take into account the electricity consumption benchmarks from the state aid guidelines on EU ETS indirect cost compensation in order to identify the necessity to include indirect emissions for the sector when including it in the CBAM.

In a next step we exclude sectors which do not have product benchmarks in the EU ETS, which is a clear sign that the products and/or production processes in those sectors are too diverse for defining benchmarks. Another reason can be that attributing emission data to products in the MRV system would be too complex for the purpose of determining benchmarks. Those are aggregated in the category "other sectors"[55], which together account for about 10% of the CL exposed EU ETS emissions. The result of this exercise is presented in Figure 4-3 in a shorter and more graphical description of the situation than the table in the Annex. It can be seen that by including only 7 sectors, 80% of EU ETS direct emissions at risk of carbon leakage could be tackled (this is approximately 33% of the EU ETS's total emissions). Coverage in practice will be smaller, as not all the products of these sectors will be suitable for inclusion in the CBAM (see Sections 4.4 and 4.5). The percentage mentioned does not, however, include the indirect emissions of some sectors with significant carbon emission reduction potential and which are highly CL exposed due to their indirect emissions (in particular aluminium production), which are included in the CBAM analysis. Such aggregation results in 12 aggregated "sectors" (without the "other sectors"), which are still a considerable number where separate assessment is needed, but reasonable for further discussion.

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[53] Commission Delegated Decision (EU) 2019/708 of 15 February 2019 supplementing Directive 2003/87/EC of the European Parliament and of the Council concerning the determination of sectors and subsectors deemed at risk of carbon leakage for the period 2021 to 2030.

[54] Note that numbers in this section include installations from the EU-27, the UK as well as the EFTA countries Norway, Iceland and Liechtenstein.

[55] We have aggregated here some sectors with product benchmarks but low emissions: Coke and "other mineral products" (including the mineral wool benchmark), and all sectors which have no product benchmarks: crude petroleum extraction, food and drink, non-ferrous metals (except aluminium), other chemicals, mining, wood-based panels, nuclear fuel processing, textiles.

Short sector name	Number of installations	Emissions [kt CO2/yr]	Number of PRODCOM codes	Cumulated emissions
Iron & Steel	485	159 861	144	22.8%
Refineries	130	132 164	10	41.7%
Cement	214	118 164	3	58.6%
Organic basic chemicals	331	64 877	168	67.8%
Fertilizers	99	36 995	30	73.1%
Pulp & Paper	672	27 233	57	77.0%
Lime & Plaster	193	26 151	6	80.7%
Inorganic chemicals	149	22 483	116	84.0%
Glass	326	18 226	47	86.6%
Aluminium	89	13 755	14	88.5%
Ceramics	350	7 810	13	89.6%
Polymers	121	5 655	50	90.4%
Other sectors	1 200	66 902	281	100.0%

Figure 4-3: ***Proposed aggregated sectors sorted by emissions.***

Using these 12 aggregated sectors, there would be 658 product categories out of the 3 919 categories listed at 8-digit level in PRODCOM 2019. The PRODCOM system is used here because the reporting rules for free allocation in the EU ETS are required for operators of installations to report their production in this system, and due to its compatibility with the NACE classification of industry sectors used for determining the CL List. However, in the administration of EU customs and taxes, CN[56] numbers are used for identifying product categories of imported or exported goods. Furthermore, the 8-digit CN codes are an extension of the internationally used (6-digit) HS classification developed under the UN. CN codes cover more commodities than PRODCOM[57]. In the following we will sometimes refer to CN codes, or where they are easier to handle because of their higher aggregation level. Mapping tables for correlating HS, CN and PRODCOM codes are available on Eurostat's website[58]. A final choice of the most useful classification system will only have to be made when a CBAM is finally defined in a legal instrument.

The identified aggregated sectors form the starting point for further discussion in the following sections. Whether an industry sector can or should be included in a CBAM depends on many factors, and trade-offs between them must be carefully balanced. In particular, a very comprehensive CBAM scope which could make the largest contribution towards enhancing the effectiveness of the EU ETS carbon price signal in support of climate neutrality while avoiding carbon leakage risks, has to be balanced against the administrative burden, the technical feasibility and the actual enforceability of such a system. Therefore, the criteria listed in Section 4.2 state that practical issues need to be considered, linked in particular to MRV issues. For this purpose, it is necessary to look at specific products, not the sectors, as at custom offices decisions and the calculation of the CBAM obligation needs to be made based on the type of product. Therefore Section 4.3.3 first outlines some consideration on how products can be defined. Thereafter the central question is discussed, namely for which products the embedded emissions

[56] Combined Nomenclature, which is the European statistical classification system compatible with the United Nation's HS (Harmonized System) used in international trade.

[57] E.g., since 2005 PRODCOM does not contain codes for refinery products such as gasoline, diesel and kerosene.

[58] E.g. for CN 2019 and PRODCOM 2019: http://ec.europa.eu/eurostat/ramon/documents/prodcom_2019/PRODCOM_2019_CN_2019_mapping.zip.

can be determined (note that this depends on MRV design choices, see Section 5.2.5). For this purpose, a discussion of the most important value chains in the EU ETS sectors is given in Section 4.4.3.

4.3.3 Defining and identifying products

For the practical feasibility of a CBAM two aspects are relevant: Firstly, the **products and materials must be defined** to a sufficient degree that the appropriate amount of the obligation[59] under the CBAM can be determined by a customs official. For this purpose, it is not enough to clarify only the (carbon leakage exposed) sector using a NACE or PRODCOM code as on the carbon leakage list, but to list specifically all the products in those sectors which are to be included in the CBAM. This has to take into account that within the NACE sectors value chains can be found, with subsequent productions steps leading to different amounts of emissions. Focus on the steps with highest emissions and including those products along the value chain that satisfy the criterion of identifiable products will help to find the right balance between administrative burden and effectiveness against carbon leakage. For applying the CBAM in practice, all product categories which satisfy all criteria for including them in the CBAM should be listed in an authoritative document (e.g. an implementing act) by specifying their PRODCOM codes (or better: CN codes), together with the applicable reference values for the embedded emissions required for defining the amount of obligation under the CBAM.

Secondly, it must be considered **whether materials and products can be sufficiently identified** in practice for making the CBAM enforceable. This means that it must be possible that a product or material is unambiguously linkable to its definition and its reference value for embedded emissions. Such distinction would be for example difficult when the same basic material products can be made of primary or secondary (i.e. recycled) materials, if differentiated treatment were allowed or required. Such differentiation can create incentives for resource shuffling, and where distinction is difficult to monitor, it may encourage fraud. The most prominent case here are metals in general, which can be easily recycled, and in particular the different production routes: blast furnace (primary) and electric arc furnace (almost exclusively secondary) steel. While it would be justifiable based on the EU ETS benchmark methodology to assign different levels of embedded emissions to primary and secondary materials even in the absence of verified emissions data, it might be quite inviting for importers to claim that their product was recycled and therefore subject to the lower CBAM obligation. The proposed approaches for avoiding incorrect claims in this regard are either to require independently verified emissions data following strict MRV rules (see Section 5.2.6), or to rely fully on default values for embedded emissions.

If those MRV rules are applied appropriately, only in rare cases of suspected fraud actual (chemical) analyses would be required to **distinguish primary and secondary materials.** Analytical methods would have to be made available to tax or customs authorities (depending on the CBAM design considered) together with reference data for selected tracer elements which would make it possible to identify non-primary materials to a sufficient assurance level. For the moment it seems an excessive effort to develop such methods. Instead, the MRV rules in the CBAM applicable to emissions from foreign countries as outlined in Section 5.2.6 will require the importer to provide credible evidence (confirmation with reasonable assurance by an accredited verifier applying international standards and in line with relevant EU legislation), which would also have to confirm what production process at which installation of provenance has been applied. For other cases of doubt, e.g. whether a certain CN code has to be applied, sufficient instruments already exist, since all kinds of custom tariffs need to be confirmed in practice, too.

[59] I.e. the amount of tax to be paid or the number of ETS allowances to be surrendered.

If both criteria are satisfied, i.e. products are defined and it is ensured they can be identified, the remaining issue is **whether the embedded emissions of a material or product can be determined**. As will be shown in Section 5.2, this question is intertwined with the design of the MRV system and the approach chosen for determining default values. However, as will be discussed, a solution will almost always be possible if the system boundaries of MRV are chosen reasonably. In order to understand what "reasonable" would mean here, we will discuss in the next section what kind of value chains have to be considered in the context of the EU ETS and the CBAM.

4.4Practical feasibility aspects

Most literature on CBAMs concentrates on only a handful of "energy-intensive and trade-exposed" (EITE) sectors, which are often not defined in detail (Böhringer, Rosendahl & Storrøsten, 2015; Cosbey et al., 2019; Flannery, Hillman, Mares & Porterfield, 2018; Kortum & Weisbach, 2017; Das, 2011; Mehling et al., 2019; Sandbag, 2019; Branger & Quirion, 2014; Böhringer et al., 2012). Furthermore, most literature rightfully assumes that focus on basic materials may make the system more realistically feasible than if taking into account more downstream products. This goes hand in hand with the expectation that for basic materials the administrative burden may remain limited. In this chapter we examine if these assumptions are correct. This is important, in particular, as in the case that only imports are included in a CBAM (Options 1 and 2), a strong incentive will be generated for producing more semi-finished or finished products outside the EU and thereafter importing them into the EU without being covered by the CBAM. This would mean that bigger parts of value chains would become subject to carbon leakage. If, however, it was possible to cover more complex products by the CBAM, the carbon price would be more effective and carbon leakage risks better addressed.

Value chains are very different in the sectors covered by the EU ETS and exposed to a risk of carbon leakage. The differences concern both the typical depth as well as the horizontal width of value chains. Therefore, it can be assumed that not all options of CBAM designs will be equally suitable for the different sectors.

4.4.1 Definitions (value chain)

One difficulty of discussing complex topics such as a CBAM comes from the fact that that many terms are difficult to define, used for different meanings in different contexts, etc. For example, the term "value chain", "upstream" or "downstream" processes are used in different ways in the literature and by stakeholders from different industry sectors. In order to provide information which is as unambiguous as possible in this report, we give definitions for some terms here. We use a very pragmatic approach instead of an exact definition that would be universally applicable. We explain the terms in exactly the way they are needed to discuss the scope and the related practicalities of MRV which are closely connected to the scope definition, i.e. in particular for Chapters 4 and 5 as follows:

- **Raw materials**: Materials which are at the beginning of any value chain and are the result of mining or quarrying, or materials such as agricultural and forestry products (i.e. biomass). Raw materials can be physically modified (e.g. in aggregate size) compared to their natural form, but usually not chemically modified before being used in a production process. We assign zero embedded emissions to raw materials.

- **(Basic) materials**: A material is either a (technically pure) substance or a mixture of substances in a physical form that can be sold, such as gaseous (hydrogen, ethylene, etc.), liquid (nitric acid, gasoline) or solid (cement clinker, polyethylene granules, metal ingots etc.), which has been derived from raw materials in an industrial process, during which their chemical composition is modified (e.g. cement clinker is the result of burning, iron ores are reduced to metallic iron/steel, crude oil is split into components by physical processes and chemical modifications, etc.). In the context of this study the term "material" implies not necessarily that it is produced by one single production step, but usually by a limited number of production steps which can usually be performed in one single installation (even if often several independent installations are involved in practice). In this context, the installations usually belong to energy-intensive sectors covered by the EU ETS.

- **Basic material products**: Formed products which consist overwhelmingly of one single basic material, and which are usually produced in a (sometimes energy-intensive) process closely coupled and performed in the same installation as the basic material. Examples are bricks and ceramic tiles, glass bottles, steel or aluminium sheets, rods, bars, coils, profiles, etc. There are often high energy saving potentials in the process if the forming step is integrated with the material production, e.g. if the still hot steel can move from continuous casting directly to the hot rolling plant. Therefore, there is little incentive to perform the forming in a separate plant, and the basic material is seldom traded without a forming step.

- **Components** (often also referred to as semi-finished products): This term would refer to products made of more than one basic material or basic material product, which thus require more complex manufacturing steps. In this category would fall steel sheets after surface treatment and covering, cutting and further forming, e.g. into sheets that have already the form of a car door, as well as car tyres. A component by itself is usually not intended for end consumers but may replace parts of a final product.

- **Final products**: By this term we would mean every product which is made of components and/or further basic materials/products. In contrast to the other products in the value chain, final products are not part of other final products. This would entail a wide range of products, including cars, mobile phones and television sets, but also simpler things such as carton-packaged aluminium foil on a roll ready for sales to end consumers.

- **Production process / production step**: By this we mean a single operation which adds value to one of the material or product categories listed above, resulting in another material or product. A value chain is the result of combining several production steps. A production process or production step in this meaning in the CBAM context is often correlated to what is done in EU ETS installations, but often one installation performs several processes leading to several products which are either directly sold or used for producing a downstream product in the same installation. In a wider sense we include also production steps outside the EU ETS in the discussion of value chains, but such non-ETS processes would usually have zero GHG attributed for CBAM purposes.

- **Value chain**: This is the sum of subsequent production steps. The value chains discussed regarding embedded emissions are always understood to include the processes from the raw material to the product discussed (i.e. relating to the specific partial product carbon footprint which relates to EU ETS processes to result in the product discussed). When discussing implications of the different CBAM options in Chapter 3, longer value chains are also possibly meant, reaching further downstream.

- **Upstream processes**: All the processes required to end up with the product or material discussed.

- **Downstream processes**: All processes in which the discussed product or material can be used. Downstream processes can reach as far as to include manufactured products intended for the final consumer.

- **Being covered by the EU ETS**: Production processes or specific GHG emissions from processes would be considered "covered by the EU ETS" in this report, if those processes and GHG emissions are listed as an activity in Annex I of the EU ETS Directive. Hence, this term should be understood to apply to installations both inside and outside the EU. This is because the term "embedded emissions" relevant for CBAM design is intended to be aligned with EU ETS emissions, no matter in which country they take place.

- **Embedded emissions**: Emissions relating to a specific partial product carbon footprint of a material or product subject to the CBAM. The definition is intended such that the CBAM obligation for a material or product can be calculated as
  Obligation = Embedded emissions x Tonnes product [x Carbon price]
  Therefore several options are proposed to define embedded emissions, depending on how broad and ambitious the design of the CBAM should be. For details see Section 5.2.1.

From the above it becomes clear that the boundaries between the material and product categories are often flexible and subjective. In some sectors the basic material product can be identical to the final product sold to the end consumer (e.g. a bag of Portland cement for the do-it-yourself market; a bag of NPK fertiliser, etc.), while other sectors require bringing together a multitude of basic materials and semi-finished products from various other sectors. Literature about a CBAM often uses terms like the above without further definition. It is therefore often not clear with respect to the real scope implied for the CBAM. In particular the boundaries between basic materials and semi-finished products, and between the latter and manufactured products can be unclear. It is therefore important that any legislation to implement a CBAM provides clear definitions of the products to be included, or at least clear criteria according to which implementing acts can later define the precise definitions. Due to the complexities mentioned the preferred approach for defining materials and products is to provide a list of the CN codes which would fall under the respective definition, instead of actually defining the product in a descriptive way.

4.4.2 Impact of the value chains on CBAM product choice

The first and most obvious argument in favour of concentrating on basic materials/products may be that the number of products to be administered by a CBAM will strongly increase with every production step, while the energy-intensive basic materials (and their carbon costs) are "diluted" in each manufacturing step. For example, in the steel sectors found on the CL List (see Section 4.3) there are 144 PRODCOM categories (including alloyed steels and ferro-alloys which will differ from "normal" steel in terms of embedded emissions). These categories refer mostly to steel materials like ingots, bars, coils, sheets, pipes etc. of various dimensions and steel qualities. They mostly fit into the above definition of "basic material products", where the larger part of the material's value actually is based on the production costs of the chemical steel making process, while the effort for bringing the steel into the form and dimension sold is some order of magnitude smaller. Therefore, several authors[60] consider the additional energy and thus carbon requirement for the additional refinement of basic materials to be small compared to the carbon intensity of the conventional primary production process. Furthermore, typically the increased value added of the subsequent refinement stages is significantly higher. Hence the initial focus resides on enhancing the effectiveness of the carbon price while avoiding carbon leakage risks for the basic material production stage.

Secondly, for practical reasons, only products should be included in a CBAM for which the embedded emissions can be determined with reasonable robustness and credibility as the basis for the definition of reference values. For basic materials coming directly out of an installation which

[60] Cosbey et al., 2019; Mehling et al., 2019; Monjon and Quirion 2010; Droege 2009; Pauliuk et al. 2016; Böhringer et al. 2018; ODI (2020); Sakai & Barrett, 2016; Gisselman & Eriksson, 2020.

monitors its emissions under a mandatory and publicly regulated carbon pricing scheme such as the EU ETS or the Korean ETS, this will be the case in principle, although it can be difficult in practice. Experience with the new allocation rules for the fourth phase of the EU ETS shows that it is often very demanding to split the emissions correctly along the boundaries of the so-called sub-installations which serve for attributing emissions to the various products leaving the installation. The situation gets the more complicated, the more manufacturing steps are subsequently carried out. It is the nature of manufacturing of more complex products, that the content of the basic materials in the final product will not always be 100%. For example, a product may consist, for instance, of 60% steel and 40% other materials. Assuming that those other materials would not lead to significant emissions during their production (they might be recycled materials or biomass), the embedded emissions of that product would be only 60% of those found for a pure steel[61]. On the other hand, for complex structures, extensive machining may be required, such that, for instance, only 25% of the original steel material end up in the product, while 75% are wasted in the form of (recyclable) scrap. In this case, the embedded emissions of the product would be four times higher based on the mass of the product than for the original steel material[62]. Furthermore, most manufactured products (for end consumers) consist of far more than two basic materials and require many production steps[63], which are often carried out by a multitude of different companies across the globe, making the tracing of the associated emissions very onerous. It is therefore desirable to find a reasonable limit regarding the number of production steps which can still be taken into account when determining the embedded emissions of a product. The term "semi-finished products" is often found in the discussion of CBAMs as the boundary of its scope, but it is rarely defined in detail. In our approach there is no need for such ambiguity, since we propose to explicitly list which products should be included in the CBAM.

Thirdly, as has already been mentioned in the introduction to this chapter, it has to be kept in mind that different industry sectors function very differently. In some cases, the "EITE[64] product" itself is a good for purchase by an end consumer. This is the case for electricity production, refinery products (gasoline, diesel), most fertilisers, some tissue or office papers, etc. In other cases, there are so many production steps before a product is placed on the market that the final customer cannot reasonably know which basic materials it consists of. Many simple and seemingly homogeneous materials are in fact complex mixtures (e.g. PVC contains significant mass fractions of stabilisers, plasticisers and other additives such as pigments). Furthermore, there are products (e.g. electronic equipment) of which the value stems more from the know-how in the production process than from the materials used. The value of a microprocessor's silicon content, its gold wire, etc. is several orders of magnitude lower than the final product value. These are cases where the embedded emissions are extremely "diluted" throughout the production process, so that any remaining potential carbon costs of the production process would not merit any consideration for a CBAM.

From the above it becomes clear that basic materials, and in some sectors, basic material products seem most appropriate for inclusion in the CBAM due to the relatively limited administrative burden which it would entail regarding:

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[61] These are rough estimates which assume that the emissions of manufacturing steps for the compound products are negligible, which is indeed often the case compared to the emissions of the base material production.

[62] One might argue that the 75% material cut off would be recyclable (through the EAF route) and would then lead to significantly lower emissions than a virgin steel produced by the blast furnace route. However, if the MRV effort is to be kept reasonable, it would be easier to fully assign all 100% steel emissions to the product under consideration, while the emissions of recycling would be fully attributed to the EAF steel which used the scrap as input.

[63] More in general, the embodied emissions could be expressed as the sum of the products of the content and the specific embodied emissions of all materials found in the product. However, there are often also materials used in the manufacturing which do not end up in the product, such as cutting tools, solvents for cleaning etc., the consumption of which would also have to be taken into account.

[64] Energy Intensive and Trade Exposed.

- the number of products for which product definitions, MRV rules and reference values need to be developed, and
- the number of transactions (imports) that need to be subject to the CBAM.

Notably, the above considerations apply more to main Options 1 to 3 (see Chapter 3). For Option 4 (excise) and Option 5 (carbon added tax), the considerations would be different. As those systems are intended to cover much larger parts of value chains, their feasibility would depend more on whether a practical method of tracking embedded emissions through potentially long and complex value chains can be established. The default values for embedded emissions, would be based on rough estimates only. Therefore, also the MRV considerations of Chapter 5 relate better to Options 1 to 3.

However, at least for those options discussed in Chapter 3 which are import-oriented (Options 1 to 3), the focus on basic materials and products will provide an incentive to produce semi-finished and final manufactured products outside the EU, as their import would then not fall under the scope of the CBAM. This is therefore discussed in the evaluation of the design options in Chapter 3. In other words, value chains would be partly pushed outside the EU, which would not only increase carbon leakage, but would lead to a further loss of value generation within the EU. In order to mitigate this effect, a purely import-oriented CBAM would benefit from inclusion of semi-finished products in its scope. This study therefore needs to discuss if that would be possible with reasonable administrative effort. This is done by discussing the most important value chains in the EU ETS in the next section.

4.4.3 Selected issues of value chains for basic materials

A crucial criterion which can impact the overall feasibility of a CBAM is the availability of data for defining reference levels for the embedded emissions of a product or material. If such data is unavailable, it would remain unknown how big the obligation for an imported product in the CBAM would be.

At this point we examine how the embedded emissions of simple materials stemming from EU ETS installations can be determined for the purpose of a CBAM. It might turn out more complex than it appears at first sight. For defining a product's embedded emissions, the literature (Cosbey et al., 2012; Mehling et al., 2019; Pauliuk et al. 2016; Böhringer et al. 2018; Moran & Hasanbeigi & Springer, 2018) often refers to the options (a) actual emissions or (b) reference values such as the EU ETS benchmarks or the EU's average emissions in a sector. This appears convincing for materials which can be produced in one single step covered by the EU ETS. However, if goods produced in the EU are to be put on equal footing with imported goods regarding embedded carbon costs, it is necessary to see whether reasonably robust data in the EU could be obtained for the relevant value chains. In some cases, such value chains can be well-defined, which means that it is possible to combine EU ETS benchmarks or average emission values for products which are usually produced via relatively uniform routes, and where material consumption in the different production steps can be well estimated. This approach is however not straightforward in the case that materials can be obtained by different (chemical) routes, where a choice for one of the possible routes will have to be made and may turn out controversial. Such considerations may be of great importance in sectors where high emissions are caused by basic materials or products which can be traded across borders. Some examples are given below:

- For the **steel industry**, the typical production route for basic material products (blast furnace route) can be simply described as follows:
    - coke (product benchmark) is produced from coal;

- some iron ores are treated in a sinter (product benchmark) or pelletisation plant;

- iron ore (or purchased pellets), coke and sinter are used in the blast furnace for producing pig iron, from which residual carbon is removed in the converter for producing steel (the "hot metal" benchmark applies to the whole process, although the calculation basis is the hot iron leaving the blast furnace);

- for a more precise treatment, various additives (in particular lime) and the often-significant amounts of scrap added to the process have to be considered;

- some more energy input is required (fallback approach "fuel benchmark") for hot rolling, cold rolling, plating, etc., i.e. for arriving at the basic material product.

From (confidential) EU ETS data, or by using information from the BAT reference document, and with the support of the industry association, it could be possible to come up with a reference value for typical steel products taking into account all the above production steps.

However, an issue of great importance in the steel sector is the fact that there is another production route (electric arc furnace) which leads to considerably lower GHG emissions than the blast furnace route. This is a consequence of the use of already metallic iron instead of iron ore in the process (either steel scrap or "Direct Reduced Iron", DRI). For EU ETS purposes it has been argued that blast furnace and EAF routes usually lead to different products and so different benchmarks for both production routes have been introduced. The reason is due to the lower purity of scrap-based steels[65]. They could therefore be distinguishable based on chemical analyses. However, when using DRI, it is doubtful if this distinction is possible. Therefore, the criterion of the possibility to distinguish materials needs to be considered in the design and evaluation of CBAM options (see Section 4.3.3).

- In the **fertiliser industry**, a few pure and emission-intensive substances are traded (ammonia, nitric acid, ammonium nitrate and urea), and other typical products are granulated NPK fertilisers of various nutrient mixtures. This is because plant growth can be improved by providing three nutrients to soils which might otherwise be insufficiently available: nitrogen, phosphorous and potassium (in chemical symbols: NPK). The only component which is produced with significant GHG emissions is the nitrogen component (which can be either ammonium or nitrate ions, urea, or mixtures thereof), and nitrogen components are also traded as pure chemicals which can also be used by other industries. The production chain is as follows (see also Figure 4-4):

  - As a first step, ammonia is produced where natural gas is almost the exclusive raw material[66]. A dedicated EU ETS benchmark exists.

  - From ammonia, nitric acid (benchmark) or urea can be produced.

  - The downstream process steps are less energy-intensive and (if carried out in standalone installations) not under the EU ETS. Urea can act as a solid fertiliser on

[65] Ecofys et al., 2009, https://ec.europa.eu/clima/sites/clima/files/ets/allowances/docs/bm_study-iron_and_steel_en.pdf

[66] In fact, the first production step is hydrogen production, for which a dedicated product benchmark exists in the EU ETS. However, this benchmark is only applicable where substances other than ammonia are produced. It is worth mentioning that the vast majority of hydrogen is currently produced from natural gas, and only in a few cases from heavy fractions in refineries. At this point in time "green" hydrogen from water electrolysis using electricity from renewable sources is not yet an economically feasible option. However, as soon as a "green hydrogen economy" becomes reality, it would also feed ammonia production.

its own or be used for NPK production. Ammonia and nitric acid can be reacted to form ammonium nitrate, which is a fertiliser on its own, or a component in NPK fertilisers.

For a CBAM this means that for all the fertilisers mentioned, the nitrogen content and the chemical form of the nitrogen component need to be known to determine the emissions. For nitric acid and nitrates, it should be possible to determine combined reference values based on the ammonia and nitric acid benchmarks. For urea production, a reference value based on the necessary ammonia quantity would be logical[67].

- For **polymers**, which are highly tradable commodities, the actual emissions of the polymerisation of monomers are relatively low, while the production of the precursors (the monomers) is highly energy-intensive. Hence, an approximation to reality may be required by taking into account the upstream processes. For example, the CBAM reference values for PE (Polyethylene) and PP (Polypropylene), the two polymers most widely produced globally, may be reasonably focused on the carbon emissions from refining and high value chemical production (steam cracker). However, for PVC (the third most widely produced polymer), one of the most complex value chains in the EU ETS can be construed (see also Figure 4-4):

    - The starting point are light fractions of the refinery products. Hence, some emissions based on the refinery benchmark[68] should be taken into account.

    - Production of simple olefins (ethylene, propylene, etc.) is usually done using steam cracking. The EU ETS benchmark for HVC ("High Value Chemicals"[69]) applies. For the next step, only ethylene is relevant.

    - For vinyl chloride (monomer) production there is again an EU ETS benchmark. Input materials are ethylene (which "carries" emissions from refineries and HVC) and chlorine[70].

    - Chlorine production is an electrolytic process which is eligible for indirect EU ETS compensation. A benchmark is found in the state aid guidelines on power price compensation for the third phase, and its production is eligible for compensation in several Member States. Chlorine production has no direct emissions and is therefore not covered by the EU ETS itself.

    - For two of the existing three polymerisation processes (E-PVC and S-PVC), EU ETS benchmarks exist.

  In this case the determination of an encompassing reference value may be difficult. Not only are the refinery and HVC benchmarks not directly useable, but the final production step can be subject to different benchmarks. It is to be expected that based on customs

[67] Furthermore, the absorption of CO_2 in the urea production process could be considered. However, at the current stage the EU ETS monitoring regulation considers this CO_2 quantity as emitted.

[68] Note that the refinery benchmark based on the CWT (Complexity Weighted Tonnes) approach is rather atypical, as it does not directly relate to the quantity of certain products such as gasoline, diesel or kerosene, but on the complexity and throughput of the whole refinery and its actual configuration. Hence, at this point in time there is not yet any agreed approach to assign CO_2 quantities to each of the refinery products.

[69] This takes into account acetylene, ethylene, propylene, butadiene, benzene and hydrogen. Note that as for refineries, no agreed methodology is available at this time for assigning specific emissions to each of the individual products.

[70] Alternative production routes use hydrochloric acid. However, although the latter may be a by-product from other reactions, at some point chlorine production is also required.

papers, no distinction between E and S-PVC can be made. The latter may, however, be a less important issue, as the significantly higher emissions stem from the other processes listed, in particular the steam cracker.

Figure 4-4 gives a more comprehensive overview of some of the most important value chains in the chemical industry (using the aggregated sectors "fertilisers", "inorganic chemicals", "organic chemicals", and "polymers"). The aim of this figure is to identify which of the processes lead to the most significant emissions in the EU ETS, which processes are eligible for indirect emissions compensation, where benchmarks are found, and whether sectors are included in the EU ETS at all. Furthermore, the different colour codes and arrow types give an insight as to whether the production processes are *typically* integrated at one site or in one installation, or whether the products can be easily transported over great distances to separate production sites. That information is currently based on expert judgement and may be refined when the actual work on defining reference default values for embedded emission starts. Where trade statistics show a large number of substances which are typically used in integrated sites for the biggest production processes, this may also be an indicator that the substance is used for more diverse applications than shown in the picture (which is the case for almost all chemicals).

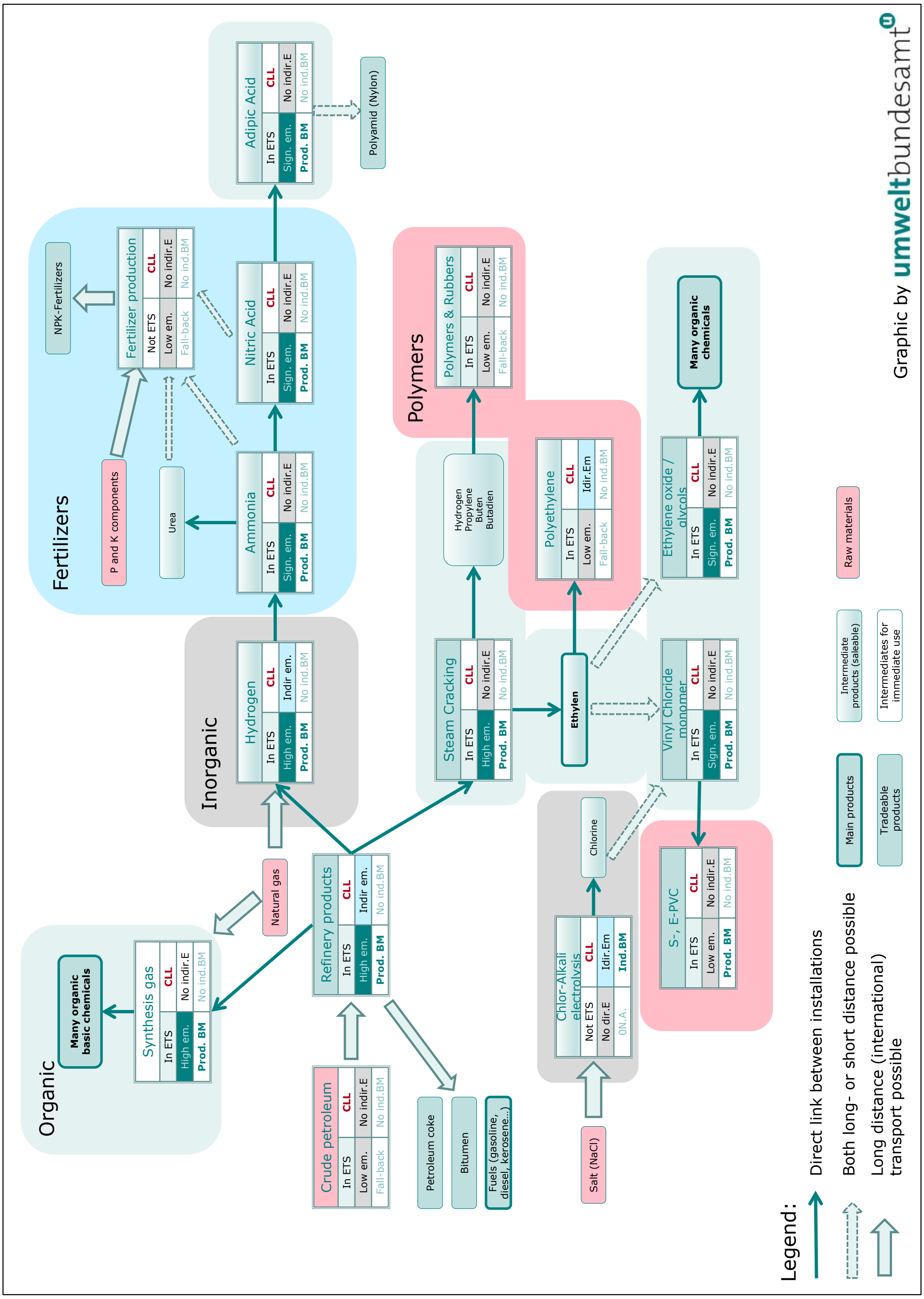

Figure 4-4: ***Overview of a part of the chemical sector's value chains. This shows that not all energy-intensive products are traded, and not all traded products are energy-intensive. It furthermore shows where product benchmarks and indirect emission compensation benchmarks are available.***

4.4.4 Feasibility to determine embedded emissions of basic materials

As mentioned before, the embedded emissions of a material or product are required to calculate the CBAM obligation, and if the embedded emissions cannot be determined at least as a reasonable default value, the material or product cannot be included in the CBAM scope. This feasibility to determine embedded emissions is discussed here.

A generic formula for determining embedded emissions EE_P of a material or product in a value chain can be expressed as follows (without taking into account any carbon price already paid or free allocation received[71]):

Equation (1) $EE_P = EM_P + IE_P + \sum_{i=1}^{n} MC_i \cdot (EM_i + IE_i)$

Where EM_P are the direct emissions of the production process of the material or product under consideration, IE_P the indirect emissions of the production process (note that according to MRV options defined in Section 5.2.3 it is possible to omit this parameter). The formula takes into account the emissions of upstream production processes, where the index *i* indicates the upstream materials 1 to *n*, and MC_i the amount of material *i* consumed for one unit of the material or product for which the embedded emissions are to be calculated. EM_i are the direct emissions during the production of material *i*, and IE_i the respective indirect emissions. This formula is relatively simple to apply to a single production step. If it is the first step of a value chain, i.e. if all raw materials used in the process have embedded emissions of zero, it is simply $EE_P = EM_P + IE_P$, and if the CBAM design were such that indirect emissions were not included (Option EE.IE.2 in Section 5.2.3), it would be reduced to only $EE_P = EM_P$. For application to a longer value chain, the formula can be used either subsequently for one production step after the other, or by applying it in one go by using MC_i values which take into account how much of the materials produced upstream pass through the value chain to result in the product or material under consideration.

From this equation it becomes apparent what data are required to determine embedded emissions, and what is required to decide if the product can be included in the CBAM.

- In case of a basic material produced in one single step covered by the EU ETS from raw materials.
    - A reference value for the direct emissions per tonne of the production process (EM_P).
    - Where relevant, a reference value for indirect emissions per tonne related to that production process (EM_P).
    - In order to determine those two values, the CBAM design needs to define a set of rules to determine them. This will apply without prejudice whether the reference values would be set at the EU ETS benchmark or at a higher level such as the average emissions intensity in the EU, or even specific to certain countries.
      The key issue here is that for all types of production processes which lead to more than one product, rules need to be defined for how to split ("attribute") emissions to those products. For those basic materials which are covered by EU ETS product benchmarks, the FAR[72] provide relatively clear rules for defining system boundaries

[71] As the present discussion is only about the purely technical arguments and description of the important value chains, there is no need to take carbon costs into account. Variations of the formula *with* carbon costs included are found in section5.2.1.

[72] Free Allocation Rules, i.e. Commission Delegated Regulation (EU) 2019/331 of 19 December 2018 determining transitional Union-wide rules for harmonised free allocation of emission allowances pursuant to Article 10a of Directive 2003/87/EC of the European Parliament and of the Council.

(so-called sub-installations), and for attributing CHP emissions into a part for heat and a part for electricity. However, there are no rules for going into more detail (e.g. splitting fallback sub-installations into more disaggregated product-specific values), and even some of the defined product benchmarks do not provide sufficient detail to assign them to the single products covered by the benchmark. For example, the refinery benchmark applies to a whole "typical product mix" of a refinery, consisting of various fractions such as naphtha, gasoline, diesel, kerosene, fuel oils etc. The same applies to the "HVC"[73] benchmark and some other chemicals benchmarks. This is no obstacle in principle to include such materials/products in the CBAM, but a considerable practical stumbling block to making it happen in practice, as the definition of the required rules may be quite controversial. Proposals for solving this specific issue include attributing the emissions to specific materials/products according to:

- the ratio of free reaction enthalpies of the chemical reactions involved;
- the molecular weights of the materials obtained;
- the relative economic value of the materials/products produced;
- a flat-rate approach (all materials/products are rated equal, e.g. a tonne of gasoline would have the same embedded emissions as a tonne of heavy fuel oil).

- In case of basic materials or products which require more than one production step covered by the EU ETS, Equation (1) can either be applied for combining all the steps of the value chain in one calculation, or each step can be assessed separately. As in most of the cases each of the production steps itself leads to a tradable material or product, it is most useful to carry out the calculation for each step separately. An overview such as Figure 4-4 can be helpful to determine all relevant value chains. The data and information needs for determining reference values of embedded emissions for implementing a CBAM include the following.
    - The reference value of the embedded emissions of each of the precursor materials, as discussed under the previous main bullet point for "one-step" basic materials.
    - The typical quantity of the precursor required to produce one tonne of the material or product under consideration (material consumption MC_i). This can be a stoichiometric factor, but more often this will have to be based on a "typical consumption level" that will require additional data collection or expert judgement, e.g. based on BAT reference documents, other literature or industry guidelines. Again, this is no obstacle in principle, but a possible source of controversy.
    - The definition of the reference production route in case of products or materials that can be obtained by quite different production routes. For example:
        - Aromatics (benzene, toluene, xylols) are basic chemicals typically produced in refineries or subsequent chemical plants. However, they are also side products of coke ovens.

[73] High value chemicals, defined as a typical output of the steam cracking process, which yields several organic bulk chemicals which are input to polymer production and other organic syntheses.

  - Ethanol is best known in public as a product of a biological process (fermentation). However, it can also be produced from fossil feedstock.

  - Hydrogen and ammonia are currently produced almost exclusively from fossil feedstock (natural gas or heavy refinery fractions) but are expected to be produced via electrolyses at large scale in the future. Already now hydrogen is a by-product of the chloralkali electrolysis process[74].

  - In the steel sector, blast furnace and electric arc furnace routes are important and can overlap regarding their product mix.

  - For several non-ferrous metals both primary and secondary production routes are of importance.

  Again, this issue is no obstacle for including products in the CBAM in principle, but its solution will be difficult from a political perspective and may draw considerable international attention.

- It goes without saying that the above data demand becomes more complex with every step down the value chain.

The application of the methodology to determine embedded emissions will need to inform the implied next process steps. In the case where the reference value will be applied to imports (main Options 1 to 3 in Chapter 3), a higher level of precision and robustness will be required. The preferred approach for solving such issues (as proposed in Section 5.2) would be that a working group under the Commission's lead consisting of Member State experts and possible consultants and industry stakeholders would develop solutions. Ultimately, this group would provide the technical basis for the decision on inclusions of materials or products in the CBAM, and on default values for embedded emissions and their input factors.

4.4.5 Practical considerations for Option 4 (excise)

The determination of the reference values for application under main Option 4 (excise, see Chapter 3) can be simpler than explained in the previous sections:

- Given the nature of an excise duty, a differentiation by production process or location would be precluded, thus only one value per material would need to be determined.

- As primary material production is more carbon and energy-intensive for all basic materials, available secondary products will typically be used first. Any additional demand will thus be served by primary products and induce the corresponding carbon emissions. Hence an efficient carbon pricing signal, e.g. the level of the excise, will need to be based on the carbon emissions of the conventional primary production process.

- The excise level will not result in distortions between installations producing the same material, neither within Europe nor internationally, as it is levied on all material production. Therefore, a lower level of precision in determining the emissions' level is required than the level typically required in the case of free allowance allocation under the EU ETS. This creates further flexibility to focus on the carbon-intensive production steps of basic materials. While this is already largely possible and anticipated in the above-

[74] However, there is also a technology called "oxygen depolarised cathode" which reduces significantly the energy consumption of the electrolysis, which avoids hydrogen production. This is useful only at chemical sites where no use can be made of the hydrogen produced.

described methods for materials like cement clinker, hot-rolled steel and aluminium, it also enhances the feasibility for inclusion of basic chemicals into a CBAM mechanism by focusing on the carbon-intensive steps in their production value chain.

The level of an excise (option 4) is applied to all domestic and imported basic materials (also as part of products). In order to ensure broader acceptance of policy choices it may be warranted to clarify the level of the default values to determine the excise already in the legal instrument.

4.5 Candidates for materials and products to be included in the CBAM

The final step for defining the scope of the CBAM is to move from the "sector" concept used in the carbon leakage list (CLL) for the EU ETS to the more tangible concept of "materials and products". For the EU ETS, it is important to use a concept that fits the installations covered, which often produce a multitude of different products. However, when an imported good is to be subjected to a CBAM, it is necessary that the authority in charge – a Member State's customs office or port authority, etc. – can identify the product imported, check whether it is to be covered, and then determine the relevant amount of emissions which are to be covered by allowances or a tax.

As discussed in Section 4.3.3, a clear definition of the CBAM will ultimately require a list of materials and products (or product classes) which should be covered by the CBAM. This list must ensure that products can be clearly identified, and emission reference values will be required to be attached to each of these products.

However, it may not be necessary to identify all the products within the selected sectors to be covered by the CBAM in its actual implementation at the stage of a Commission proposal for a CBAM to be decided in the Codecision procedure. It could be more useful to leave these technical details for daughter instruments, e.g. an Implementing Regulation which can be regularly updated in consultation with a Member State committee. The same approach might be useful for defining other technical details such as monitoring rules and actual default values for the embedded emissions of various products. It would allow for taking into account technological progress and the development of new product groups, or for gradually introducing products along the value chain when more data becomes available.

Table 4-1 presents the candidate materials/products from which the scope of the CBAM can be defined. The table follows the logic of starting with simple ("single-process") basic materials and going along the value chain to basic material products and in rare cases semi-finished products. The table provides an insight into what data is required and whether it is already available. In the column "Include in CBAM?" the table gives a recommendation on whether the material or product should be included in the CBAM. The indicators "possible" or "tbd" (to be decided) show that the inclusion should in principle be technically possible, but that at this stage the data is not sufficiently available, i.e. it would be up to the data collection approach for embedded emission default values (options given in Section 5.2.5: by actual MRV data or by expert judgement of an expert group) to provide the basis for the decision if the material or product can be included in the CBAM.

Bigger groups of CN/HS codes have been grouped into material and product groups for the purpose of Table 4-1. The materials/products are named in the first column of that table. **In Appendix 3**: Supplementing tables for Chapter 5 on the sectoral scope of the CBAM**, Table A-4 gives an example how the proposed products can be defined by correlating them to the appropriate HS or CN codes for a clear definition.**

Materials and products are considered to be within the same group where production processes suggest that the level of embedded emissions (EE_P) are similar. Separate materials/products are listed where the embedded emissions are considered significantly different. However, more work (involving industry experts) in the future would be required for determining the relevant values. Where EE_P turn out to be on a sufficiently similar level, product groups might be combined into one material group, or extended by adding further CN codes. Such design choices are also dependent on the main CBAM option chosen. For an excise duty (Option 4), EE_P levels do not have to be perfectly exact, as they would not have to fully relate to actual emissions. It would be sufficient if they provide a reasonable differentiation between materials for incentivising the use of materials with lower embedded emissions on average.

Table 4-1: Material and product categories, data requirements and considerations for inclusion in the CBAM, for selected aggregated sectors.

Notes. Under "Include in CBAM?" the meaning of the entries are as follows: "Yes": Product can be included in the CBAM based on practical feasibility considerations; "No": Product does not appear suitable. "tbd" (to be discussed): at the current stage it is unclear if practical obstacles can be solved; "possible" means inclusion should be possible in practice, but either data is not sufficient or the merits of inclusion are not clear yet. Where "tbd" is given in combination with yes or no, it means that "yes" or "no" are not as clear-cut as without "tbd". The decision on inclusion of such products requires that more information is to be collected.

CBAM Product name	Precursors	Data needs	Include in CBAM?	Other comments
Iron & Steel (HS 72)				
Pig iron	Coke, sintered ore	*MCi* of Coke, sintered ore, EE_P of coke and Sintered ore; EE_P of "hot metal", correction factor for not making steel	No	Reference EE_P required for other steel products; Do not include product in CBAM, as imports are negligible
Ferro-Alloys			No (tbd)	Too diverse products, no EU ETS BM data. Inclusion can be re-evaluated in a few years
DRI (Direct Reduced Iron)		Process route and precursors, EE_P	No (tbd)	More efficient than conventional iron making. May become increasingly important as low-carbon technology. Inclusion can be re-evaluated in a few years
Iron and steel Scrap			No	Too diverse, and no emissions attached
Iron & steel primary forms	Coke, sintered ore	*MCi* of Coke, sintered ore, EE_P of coke and Sintered ore; EE_P of "hot metal" - Alternatively EAF steel different EE_P?	possible	Includes largest import category (720712 - Semi-finished bars, iron or non-alloy steel <0.25%C, rectangular, nes), which might be EAF steel? Needs further information from the sector; Reference EE_P required for calculating hot-rolled steel, i.e. is precondition for "hot-rolled steel"
Hot-rolled & further steps	"Hot metal" (EU ETS BM) / iron & steel in primary forms	*MCi* of hot metal (or estimate as 100%), EE_P for "hot metal"; correction factor for hot rolling (based on fuel input, not available from EU ETS data)	possible	Promising candidate (often mentioned in literature). Proposal here to include also cold-rolled products (which includes a step after hot rolling)
Coated hot-rolled & further steps	Hot-rolled gsteel	Use EE_P of hot-rolled steel as proxy?	Tbd.	Coatings are very diverse, may have significant impact on EE_P. However, if not enough data available, propose to use EE_P of hot-rolled steel as a proxy. Would require additional expertise on coating processes. Inclusion might be interesting due to including a step on the value chain. If not included, re-evaluate in a few years
Forged, extruded, wire etc.	Hot-rolled steel or hot metal	EE_P of hot-rolled steel might serve as proxy	no (tbd.)	Processes covered quite diverse. Imported volume not too great.
Stainless steel	scrap and ferro-alloys	*MCi* levels of precursors, EE_P thereof (unknown), EE_P of EAF high alloy steel (EU ETS BM)	No (tbd.)	Danger of too diverse products and lack of reference data. Inclusion can be re-evaluated in a few years
Other alloyed	scrap and	*MCi* levels of precursors, EE_P thereof (unknown),	No (tbd.)	Danger of too diverse products and lack of reference

CBAM Product name	Precursors	Data needs	Include in CBAM?	Other comments
steel	ferro-alloys	EE_P of EAF high alloy steel (EU ETS BM)		data. Inclusion can be re-evaluated in a few years
Iron & steel articles (HS 73) Note: These products seem to consist to a very high percentage of cast iron or steel. The reference value of the corresponding basic material could serve as a proxy for embedded emissions of the (manufactured) product. These products can be considered for inclusion if the goal is to include more steps down the value chain.				
Article of iron or steel		Composition data in most cases not specified, hence no EE_P data know. Perhaps use “hot-rolled steel” as proxy.	No (tbd)	General problem here: Many products (the most traded ones) are "n.e.s.", hence too diverse. Furthermore, most product groups cover both "iron or steel", i.e. EE_P quite uncertain
Article of cast iron	Pig iron (hot metal with correction factor)	Correction factor for converting "hot metal" into "cast iron"; MCi assumed as 100%; EE_P for iron casting (EU ETS BM)	No (tbd)	Not very high imports
Article of stainless or alloy	Stainless steel	use stainless steel EE_P as proxy	No (tbd)	Not very high imports
Article of Steel	(hot-rolled) steel	use hot-rolled steel EE_P as proxy	No (tbd)	Not very high imports
Refineries (HS 271)				
Standard Refinery products		Derive a proxy EE_P as average of refinery outputs (will require Eurostat data combined with EU ETS data), since CWT benchmark is not directly linked to products	tbd	Product definition: Naphtha (required for chemicals EE_P); motor spirits, jet fuels, gas oils, fuel oils; Tbd if sector structure is suitable for CBAM (Global equilibrium of refining capacities); The definition of embedded emissions may be difficult, which has an impact on basic organic chemicals and polymers, which require reference values of refinery products.
Special refinery products			no	Define these products as "everything not covered by "Standard Refinery products"; Products are very diverse, probably insufficient data available
Cement (HS 25)				
Clinker		EU ETS data for developing EE_P	yes	good data availability due to simplicity of product
Portland cement	clinker	*MCi* for clinker, EE_P of Clinker	yes	good data availability due to simplicity of product; simple value chain
White & coloured cement			no	Various niche products (EU ETS BM for white clinker not generally applicable), propose to omit for reducing admin burden
Aluminium (HS 76)				
Aluminium		EU ETS data and data on indirect emissions (State aid GL)	yes (tbd)	Discussion regarding electricity mix and resource shuffling likely. However, product is reasonably homogeneous. Problem to distinguish primary and secondary aluminium.
Aluminium alloyed		Use same reference data as for non-alloyed aluminium as proxy	yes (tbd)	Big diversity of alloys possible. However, pure Al reference value should be a reasonable proxy
Other Al products (HS 76)		Use same reference data as for non-alloyed aluminium as proxy	yes (tbd)	For including at least limited value chains, this should be included, too.
Pulp and Paper (HS 47 & 48)				
Pulp			no	HS/CN codes seem to be not aligned with EU ETS benchmark classification. Data situation complex. Specific emission costs relatively low due to biomass use. Propose not to include in CBAM, since admin burden might exceed the benefit (CL impact will be limited)

CBAM Product name	Precursors	Data needs	Include in CBAM?	Other comments
Paper	pulp		no	Identification of products seems possible. However, Limited CL impact (see pulp), determination of EE_P difficult.
Fertilisers (HS 31)				
Ammonia		EU ETS data and data on indirect emissions (State aid GL)	yes	Product simple to identify; However, for aqueous solutions concentration would have to be known (apply EE_P to 100% Ammonia)
Urea	Ammonia	*MCi* and EE_P of ammonia. Under current EU ETS legislation (M&R Regulation), there is no subtraction of CO_2 bound in the urea production process.	yes	Product simple to identify; However, for aqueous solutions concentration would have to be known (apply EE_P to 100% Urea)
Nitric acid	Ammonia	*MCi* and EE_P of ammonia plus EU ETS data for nitric acid production.	yes (tbd)	Nitric acid imports do not seem to be very big. However, even if not included in the CBAM, the calculation of EE_P would be required as a precursor to other nitrogen or NPK fertilisers
AN (Ammonium Nitrate)	Ammonia, Nitric Acid	*MCi* and EE_P of ammonia and nitric acid	yes	Product clearly identifiable (including due to safety requirements). Provided the required precursor data is available (see above)
Mixed N fertilisers	Ammonia, nitric acid and/or urea	EE_P and *MCi* of the three N components NH_4, NO_3 and Urea. Fertiliser grade must be known, as this can be converted into *MCi* values.	yes (tbd)	All combinations of Urea, NH_4 and NO_3 content can be taken into account. Covers also NP, NK and NPK fertilisers. Challenge for CBAM implementation: The concentration of the three N components have to be known (must be declared by the producer anyway for demonstrating compliance with fertiliser regulations), and their concentration must be converted to one single number which defines the CBAM obligation. For some substances (CN codes), default values can be defined based on stoichiometry (e.g. ammonium sulfate or ammonium phosphates). Despite this complexity, inclusion of this product class would ensure that the complete value chain of fertilisers is included.
Inorganic chemicals (HS 28)				
Hydrogen		EU ETS data for hydrogen production.	Possible	Needed for defining EE_P of other chemicals. However, currently not much traded. In the future, when "green" or "blue" hydrogen become more important, it might be necessary to introduce a "guarantee of origin" system (depends on general CBAM design: if only default values for EE_P were used instead of actual MRV data of the producer, such distinction would be irrelevant).
Soda ash		EU ETS data for soda ash production.	Possible	Relatively simple product definition (basic material product)
Carbon black		EU ETS data for carbon black production.	Possible	Relatively simple product definition (basic material product, although many grades available)
Other inorganic chemicals			No	Too diverse products, many of them not associated with significant embedded emissions
Organic basic chemicals (HS 29)				
HVC (high value chemicals / lower olefins)	Naphtha (refinery fraction)	Derive a proxy EE_P as average of HVC (steam cracker) outputs (will require EU ETS data), since HVC benchmark is not directly linked to products.	possible	According to free allocation rules, the covered substances are acetylene, ethylene, propylene, butadiene, benzene and hydrogen. Therefore, need to derive a proxy EE_P as average of HVC outputs (will require additional data, or involvement of further experts, as EU ETS data is not sufficient), since HVC benchmark is not directly linked to individual

CBAM Product name	Precursors	Data needs	Include in CBAM?	Other comments
		Precondition is that an EE_P value for naphtha production can be determined.		products. Defining an EE_P value is pre-condition for including plastics in the CBAM.
Aromatics	Refinery products	Derive a proxy EE_P as average of aromatics outputs (will require EU ETS data), since aromatics benchmark is not directly linked to products. Precondition is that an EE_P value for refinery products can be determined.	Possible	May cover: benzene, toluene, o-xylene, p-xylene, m-xylene and mixed xylene isomers, ethylbenzene, cumene, cyclohexane, naphthalene, anthracene. FAR do not contain exact list of substances. Problem may be that the precursors can be several refinery intermediate fractions. Defining an EE_P value is pre-condition for including Some other products (styrene, phenol, polystyrene) in the CBAM.
Styrene	Benzene (see aromatics), Ethylene (see HVC)	Derive a proxy EE_P based on *MCi* and EE_P of benzene and ethylene (both not simple to determine)	Possible (tbd)	Defining EE_P onerous as aromatics data not simple to determine. Not proposed at this stage, although it would be a precondition for inclusion of PS (Polystyrene).
Phenol	Cumene (see aromatics or via benzene and propylene)	*MCi* and EE_P of Cumene required; resulting EE_P must be split into parts for phenol and acetone.	Possible (tbd)	Defining EE_P too onerous to propose at this stage
Ethylene oxide/ ethylene glycols	Ethylene (see HVC)	*MCi* and EE_P of Ethylene required; EU ETS data on Ethylene oxide benchmark.	Possible (tbd)	Resulting EE_P may apply to all glycols, but stoichiometric factors would apply
Vinyl chloride monomer (VCM)	Ethylene (see HVC), Chlorine (only indirect emissions)	*MCi* and EE_P of Ethylene required; EU ETS data on VCM benchmark. Tbd if indirect emissions of Chlorine production should be included, and how.	Possible (tbd)	EE_P value needed, if PVC is to be included in CBAM.
Methanol	Syngas	EU ETS benchmark data needed for syngas, *MCi* and emissions from Methanol synthesis to be determined from other sources	Possible (tbd)	Syngas as energy-intensive product is not traded but used on-site. Methanol and Formaldehyde are the most common products of syngas. Determination of EE_P not straightforward.
Formaldehyde	Syngas	EU ETS benchmark data needed for syngas, *MCi* and emissions from Formaldehyde synthesis to be determined from other sources	Possible (tbd)	Syngas as energy-intensive product is not traded but used on-site. Methanol and Formaldehyde are the most common products of syngas. Determination of EE_P not straightforward.
Ethanol	Ethylene (see HVC)	*MCi* and EE_P of Ethylene required	Possible (tbd)	Ethanol can alternatively be produced by fermentation of biomass. Treatment in CBAM like distinction blast furnace/EAF steel: If differentiation is desirable, a kind of guarantee of origin system could be envisaged.
Acetone	Propylene (see HVC) or as by-product from Phenol	*MCi* and EE_P of Propylene required, or alternatively a stoichiometric factor for converting the EE_P value of Phenol.	Possible (tbd)	Determination of appropriate EE_P value may be controversial.
Other organic basic chemicals			no	There are about 260 HS product categories of this type. For some of them it might be possible in the long run to define proxy values for EE_P. However, based on experience from the EU ETS benchmarking exercise, this would be very onerous.
Polymers ("plastics")				
PE (Poly-ethylene)	Ethylene (see HVC)	*MCi* and EE_P of Ethylene required	possible	Inclusion in CBAM depends on data availability, but makes sense due to the large amounts produced and traded. For a better EE_P value, additional emission data (covering the polymerisation process) would be required.

CBAM Product name	Precursors	Data needs	Include in CBAM?	Other comments
PP (Polypropylene)	Propylene (see HVC)	*MCi* and EE_P of Propylene required	possible	Inclusion in CBAM depends on data availability, but makes sense due to the large amounts produced and traded. For a better EE_P value, additional emission data (covering the polymerisation process) would be required.
PVC (Poly-vinylchloride)	VCM (see above)	*MCi* and EE_P of VCM required; depending on production process, S-PVC or E-PVC benchmark data from EU ETS used.	tbd	Inclusion in CBAM depends on data availability, but makes sense due to the large amounts produced and traded. Two out of three polymerisation processes have EU ETS data. Not clear if CN codes can distinguish between the polymerisation processes. Potentially one EE_P value for all PVC would be required.
PET	Terephthalic acid (from p-Xylene, see aromatics), and ethylene glycol (see above)		No	Determination of appropriate EE_P value onerous. Same EE_P could apply to several products (Polyesters) in HS groups 54 and 55 (man-made fibres).
PS	Styrene (see above)		No	Determination of appropriate EE_P value onerous.
Other polymers and copolymers			no	Too many, too different products

4.6 Conclusion: identification of options of scope

The final conclusions on selecting specific sectors and/or products for a CBAM depend to some extent on the main design option chosen (for a description and assessment of those options see Chapter 3). For all the options it is important that the administrative burden of the CBAM must be balanced against the achievable results. For reasons of avoiding carbon leakage risks in value chains in the EU, some options also warrant the consideration of basic materials as part of semi-finished or even manufactured products, while for practical reasons the focus on basic materials is usually to be preferred. Furthermore, it is important from a practical perspective that products covered can be clearly identified and distinguished. For options which require or allow the use of actual emission intensity levels, robust and feasible rules for monitoring, reporting and verification are required. Finally, it is essential that an appropriate default value for the emission intensity level of the materials or products included can be defined. The level of precision required differs: for an excise duty, a rough estimate may be sufficient, while a design option imposing the default value only on international trade, using actual values on emissions intensity will require default values which are robust.

Here we summarise conclusions from the previous considerations of this chapter for the two main Options 1 (Options 1a and 1b, a CBAM for imports) and Option 4 (excise charge).

4.6.1 Possible scope for Options 1a and 1b (CBAM on imports)

Here we propose a possible scope of a CBAM on imports with various ambition levels:

- Level 1, suitable for a first test phase could include the products listed in Table 4-2, under the condition that all the relevant reference values can be determined before the start of the mechanism using a reasonably robust methodology. Note that “polymers” are a borderline case, i.e. their inclusion depends on the technical possibility of defining reference values for embedded emissions. Hence, polymers might be considered Level 2.

- Level 2: With increasing political ambition and subject to progress on data collection, further products and sectors as listed in Table 4-3 could be included, on top of those already in “Level 1”. For refinery products it is debatable whether they should already be included in Level 1. This would depend on the possibility of determining default values for refinery products, which would require significant input to the technical debate from sector experts.

- Level 3 would include all basic materials and basic material products with significant emission intensity in the sectors on the carbon leakage list, i.e. all sectors identified at risk of carbon leakage. This would in particular mean pulp and paper, glass, ceramics, lime, plaster, and other non-ferrous metals (copper, zinc, etc.).
- Level 4: For the long-term perspective, subject to progress made on data availability for manufactured products, it might be possible to include some steps further down the value chain using a very simplified product carbon footprint approach.

The administrative complexity as well as the difficulty to define embedded emissions increases strongly from Level 1 to 4.

Table 4-2: Minimum scope (i.e. "Level 1") proposed under main Options 1 to 3 (sector and product names refer to those used in Table 4-1).

Sector	Materials or products	Remarks
Cement	Clinker Portland cement	Simple definition of product, embedded emissions easy to determine and agree; value chain well covered
Iron & Steel	Iron & steel primary forms Hot-rolled & further steps Coated hot-rolled & further steps Forged, extruded, wire etc.	The proposed products will be feasible under the condition that a uniform reference level for embedded emissions can be determined and agreed. Although the literature often focuses on "hot-rolled steel", it can be assumed that a similarly broad product range is meant. However, with a higher level of ambition regarding "true" embedded emissions, separate reference levels may need to be determined.
Aluminium	Aluminium Aluminium alloyed Other Al products (HS 76)	The proposed products will be feasible under the condition that a uniform reference level for embedded emissions can be determined and agreed. A difficulty may be the definition of the appropriate emission factor of the electricity mix implied for indirect emissions. With a higher ambition level for precision of the embedded emissions, it may be necessary to distinguish different reference values for alloyed and "other" products.
Fertilisers	Ammonia Urea Nitric acid Ammonium Nitrate	Products are relatively simple and clear to identify. As data from the EU ETS should be sufficient for determination of reference embedded emissions levels, it should be feasible to include these products in the CBAM.
Polymers	PE (Polyethylene) PP (Polypropylene) PVC (Polyvinylchloride)	There are several obstacles to defining robust reference values for the embedded emission levels. However, large-scale imports, high embedded emissions and the relatively clear definition of products make this product group attractive for inclusion in the CBAM.

Table 4-3: ***Possible scope extensions after a first testing phase proposed under main Options 1 to 3. The materials and products listed in this table would be added to the CBAM scope already given by Table 4-2 when moving from ambition "Level 1" to "Level 2".***

Sector	Materials or products	Remarks
Refineries	Standard refinery products	Although the product definition would be relatively simple, it is not clear if this sector can be included. There is insufficient EU ETS data which would allow the determination of reference emissions levels, and it is unclear if the sector is prepared to be included. The strong link to the chemical sector would suggest that at least a reference value for refinery products should be determined as soon as possible.
Inorganic chemicals	Hydrogen Soda ash Carbon black	For difficulties on determining relevant reference values see Table 4-1
Basic organic chemicals	HVC (high value chemicals / lower olefins): acetylene, ethylene, propylene, butadiene Aromatics: benzene, toluene, o-xylene, p-xylene, m-xylene and mixed xylene isomers, ethylbenzene, cumene, cyclohexane, naphthalene, anthracene Styrene Phenol Ethylene oxide/ ethylene glycols Vinyl chloride monomer (VCM) Methanol Formaldehyde Ethanol Acetone	Sector requires more data than available from the EU ETS, and very high technical understanding for defining the relevant reference values for embedded emissions. For difficulties on determining relevant reference values see Table 4-1
Polymers	PET PS (Polystyrene)	These two polymers are globally the most important ones in terms of quantity after PE, PP and PVC. For difficulties on determining relevant reference values see Table 4-1
Fertilizers	Mixed N fertilisers	Include the rest of the value chain. One complication is that the level of CBAM obligation is to be calculated based on the nutrient concentrations declared.
Iron & Steel	Pig iron Ferro-Alloys DRI (Direct Reduced Iron) Stainless steel Other alloyed steel	For difficulties on determining relevant reference values see Table 4-1. Embedded emissions will strongly deviate from standard (blast furnace based) steel.
Iron & steel articles (HS 73)	Article of iron or steel Article of cast iron Article of stainless or alloy Article of Steel	Including these products would help cover a significant part of the value chain.

4.6.2 Possible scope for Option 4 (Excise charge)

This option aims at the inclusion of carbon costs in downstream products and thereby making low emission products attractive to consumers, while the main instrument for reducing the risk of carbon leakage would remain free allocation. The system would treat imported and domestically produced materials and products completely equally. Therefore, it would be possible to apply more estimation methods and simplifications in the determination of embedded emissions, and much wider product groups could be assigned for the same reference value. For example, it would be possible to treat all iron and steel products with the same reference value, but also all polymers, etc. The effort for setting up the system would therefore be smaller, and it could start with a wider product range from the beginning.

More discussion of this option would be needed, but at the current stage it seems feasible that the system could start at least with the same ambition as given for "Level 1" in Section 4.6.1 and a part of Level 2. The "other sectors" (Level 4) might also be worth further consideration already at an early stage, while the proposed "Level 3" would be automatically included via the mechanism of passing on the liability to downstream producers and consumers.

4.7 Temporal considerations

The European Green Deal suggests that a gradual introduction of a CBAM is a realistic option. The large number of practical issues to be solved before the start of a CBAM (as outlined in Chapters 4 and 5) may also justify the need for a kind of learning phase before the CBAM is implemented at the widest possible range. This report therefore assumes that it may be helpful for policy development that the CBAM be introduced gradually (lower reference values for embedded emissions, less stringent MRV requirements, etc. in the beginning). Also, the number of included sectors, products and materials could be smaller in the beginning, and the types of materials and products covered might be extended to those more difficult to monitor only at a later stage. Also, other countries' climate ambitions and implemented policies (including carbon pricing) will inevitably evolve over time. Regular revision of the CBAM's scope seems therefore imperative, and legislation should be designed to allow sufficient flexibility. There is hope that at some time a CBAM will no longer be needed, as soon as the risk of CL is no longer relevant, because a significant part of the world has sufficiently raised climate ambition and put carbon pricing or other effective climate policies in place.

5. Qualitative Assessment of Certain Aspects of the Options

In essence, a CBAM consists in applying a carbon price to emissions related to goods (basic materials, basic material products, semi-finished products and/or manufactured products) that are traded across borders. This is true for all main Options 1 to 4. However, each of the elements of the CBAM merits closer attention: what is the appropriate reference carbon price? What are the embedded emissions? How is the carbon price applied, and in particular, how are free allocation and compensation for indirect costs reflected? What form does the payment take and what procedure is followed? For each question, several answers are possible, which are discussed in the following (Sections 5.1 to 5.4). In Section 5.5 we present the preliminary conclusions on these aspects. Given the distinct nature of excise duty, additional questions relating to it are presented separately in Section 5.6. The remainder of the chapter is devoted to special questions: particular problems arise when it comes to the interaction of the CBAM with climate policies in other countries. While it is often proposed to take these into account when determining the obligations under the CBAM, we will demonstrate in Section 5.7 how difficult a detailed consideration of a carbon price would be. Exemptions would be less complex, but would entail problematic incentive effects when applied to imports from LDCs. Exemptions should, however, be applied to imports from countries whose ETS is linked to the EU ETS. After this discussion of interaction of the CBAM with other countries' policies, Section 5.8 discusses the impacts of the CBAM with the EU's most important domestic policy instrument, the EU ETS. An estimate of the administrative costs of the different CBAM options concludes this chapter (Section 5.9). Appendix 1: Overview of options discussed in this report contains an overview of all the options for implementation provided in the report.

The trade of electricity is quite different to the trade of tangible goods. Due to these particularities, the design of a CBAM for the power sector would have to be conceptually quite different. Therefore, options for a CBAM approach to imported electricity is discussed separately in Chapter 6.

5.1 Definition of the appropriate Reference Carbon Price in the EU

For all design options of a CBAM except for the surrender of normal EU ETS allowances, there is a need to define a reference carbon price[75] to be used. The reference price should be set so as to align the CBAM obligation as closely as possible with the price faced by producers covered by the EU ETS. Therefore, the starting point would be in any case the price of allowances in the EU ETS. While there is currently no such thing as an "official allowance price" in the EU ETS, the latest clearing price of the common EU ETS auctioning platform (currently EEX[76]) may be useful as a starting point, since it reflects the price when EUAs enter the market. For practical reasons (limiting administrative burden and enhancing legal certainty), longer intervals than single days seem useful, if the reference carbon price has to be "officially" defined and published. By contrast, intervals shorter than a day for defining a reference price would not add much value to the functioning of the CBAM. Therefore, we propose the following options:

- Option CP.1: Uniform carbon price for the whole EU ETS trading period;

[75] Note that the term "carbon price" is a bit misleading, as it refers to one metric tonne of CO_2 equivalent, not 1 t carbon (C), where 1 t C equals 3.664 t CO_{2e}. Better terms would be "allowance price" or "CO_2 price", which should be understood as synonyms to "carbon price". Nevertheless, for simplicity of reading and given its common use in other literature, the term "carbon price" is used in this report, too.

[76] Auctioning reports can be found under https://www.eex.com/en/market-data/environmental-markets/eua-primary-auction-spot-download.

- Option CP.2: Carbon price determined once a year based on last year's average auction prices;
- Option CP.3: Carbon price determined once a month based on last month's average auction prices;
- Option CP.4: Daily actual allowance price (based on the previous workday);
- Option CP.5: Current market price (only relevant for EU ETS allowances).

Option CP.1 (uniform value for whole trading period) may be useful in cases where it is desirable to provide long-term certainty, and where it might e.g. be needed to lay down such value in legislation which is seldom changed. Such situations are known e.g. for the penalty under the EU ETS (EUR 100 per tonne CO_{2e})[77], or for the determination of what constitutes "unreasonable costs" for the purpose of the monitoring plans[78] under the EU ETS. Such an approach is pragmatic and therefore useful, but finding the right level may be difficult. Looking to the future, it could be based on model results such as those used for the impact assessments of the EU's climate legislation. However, for the purpose of the CBAM an approach closer to the reality of the EU ETS price seems necessary. If the risk of carbon leakage is rising over the EU ETS trading period due to the increasingly tightening cap and increasing allowance price, the CBAM would not be sufficiently stringent if the carbon price is not updated. Conversely, if the carbon price declined over time, imports would be subject to a higher burden than domestically produced goods. Option CP.1 is therefore not pursued further.

Option CP.2 (annual values) seems relatively simple to implement. It would require the Commission (or a "CBAM authority" as proposed in Section 5.4.1) to publish an annual "official" reference price. Article 10(5) of the EU ETS Directive already requires the Commission to prepare a report on the functioning of the EU ETS (the "Carbon Market Report"[79]). These reports give information on the auctioning results. While these reports are usually published in the autumn for practical reasons (inclusion of information only available at the end of June each year), the specific information on the carbon prices could be published earlier. This would be desirable, in order not to have a schedule where one year's carbon price is useable only two years later[80]. As an alternative, either the reference period or the applicability period of the published price could be different from the calendar year. For example, the Commission could, by the end of November 2022, publish the average allowance price of the period from November 2021 to October 2022, for use in the CBAM during the whole calendar year 2023[81]. An annual reference period (implying an infrequent updating of the reference carbon price) could be useful for Option 4 (excise), in order to keep its implementation simple.

Option CP.3 (monthly values) seems relatively simple to implement, too. Compared to CP.2, it has the advantage of reflecting a more up-to-date value. However, for this option it would be preferable not to publish the value in the OJ, as such procedure would inevitably lead to a delay which would partly invalidate the advantages of the higher publication frequency. A direct entry in the CBAM facility by the Commission or the CBAM authority would be preferred, and could provide

[77] It "*shall increase in accordance with the European index of consumer prices*" (Article 16(4) EU ETS Directive).

[78] The Monitoring and Reporting Regulation (MRR, Commission Implementing Regulation (EU) 2018/2066) uses a reference price of €20 without further justification, demonstrating it as nothing else than a design choice agreed by Member States experts.

[79] The latest such report can be found at https://ec.europa.eu/clima/sites/clima/files/news/docs/com_2020_740_en.pdf.

[80] If the average CO_2 price of 2020 were published only by the end of 2021, it would then be used for the CBAM in 2022.

[81] Publication periodicity should be well defined in the CBAM legislation in order to avoid disputes about the figure to be used. There could be, for instance, the requirement to publish the figure in the Official Journal (OJ) of the EU, or just under a specified address on the Commission's website or in the "CBAM facility" proposed in section 5.4.1.

a feasible option for all the implementation design options described under Section 5.4.1, except where EU ETS allowances are used as "payment modality", i.e. for main Options 1 to 3.

Option CP.4 (daily values): This option would reflect the EU ETS' current value even better. However, unlike options CP.2 and CP.3, this option should be considered only if it is possible to make the reference carbon price known to all relevant actors (importers, customs offices and also, if applicable, competent authorities and third-party verifiers) in an effective and timely manner. In other words, such daily prices should be automatically transferred to the system used for calculating the CBAM obligation for an import (the CBAM facility). Under this condition, CP.4 could be used by all main Options 1 to 3 and using the "payment modalities" tax or notional allowances (Options Pay.1 and Pay.3, see Section 5.4.1).

Option CP.5 (current market price): This would mean the current (intraday) price at any moment of a day, as determined by auctioning or trade on the secondary market. For practical reasons (prices may slightly deviate between marketplaces, etc.) it seems to be feasible only for buying normal EU ETS allowances (EUAs). As is discussed in Section 5.4.2, notional allowances should be non-tradable, i.e. their price would not be determined by supply and demand. Their price would therefore have to be coupled to an EUA price, which for practical reasons would be preferably a daily (or possibly monthly) reference price.

5.2 Options for Embedded Emissions ("Carbon Content") of imported products and corresponding MRV rules

This section starts by explaining the term "embedded emissions" (Section 5.2.1) and distinguishing it from other product carbon footprint approaches (Section 5.2.2). We will then show that several definitions of embedded emissions are possible (Section 5.2.3). Based on these definitions, we discuss what kind of data need to be monitored, reported and verified (Section 5.2.4). As will be shown, there are more data required than currently available for purposes of the EU ETS, at least for some of the CBAM design options. Consequently, it will be necessary to discuss what to do if data for some variables are not available through the MRV process but are required to determine the CBAM obligation, i.e. the payments to be made for imports. Default values for these variables will be required in that situation, in particular for the embedded emissions of imported goods. Section 5.2.5 describes possible mechanisms for determining such default values at EU level. Next, Section 5.2.6 discusses the possibility for CBAM importers to use actual data for embedded emissions provided by the producer of the imported goods. Another question which requires discussion is how a "compliance cycle" for the CBAM could work in practice, i.e. how the timing of MRV and of compliance and enforcement measures could be set up (Section 5.2.7). Following discussion of these considerations and the possibilities for practical implementation in Section 5.3, we propose conclusions on how to implement the CBAM's MRV system in Section 5.5.

Assumptions for further development of the CBAM

It is assumed that there will be a technical working group convened by the Commission for developing the CBAM in detail (possibly supported by external consultants, and working in close contact with industry stakeholders where necessary) which develops the detailed implementation rules and elements before the system actually starts. It will be of prime importance that this development focuses on the feasibility of the various MRV options, and on how to come up with reasonably robust default values for embedded emissions per material or product category. **Successful setup of the MRV system will have an important influence on almost all the other design elements of the CBAM, in particular on the scope of the CBAM** (Chapter 4). It makes sense to include a certain product category in the CBAM only if MRV rules can be defined and if suitable default values can be derived. MRV rules also impact on whether a differentiation between imports from different countries can be implemented e.g. by taking into account carbon pricing systems in place there (Section 5.7). MRV options also impact on whether CBAM obligations should be paid immediately at the time of import or only after regular reconciliation in a kind of compliance cycle (see 5.4.1).

Because of this assumption that further details have to be developed at a later stage, this section focuses primarily on the best case in which "all necessary data can be determined", and then gives perspectives for simplifications that can be applied in case of suboptimal data availability. Hence, instead of giving strict advice on what option would be "best", there is a building block system from which the different options can be chosen. If one option then proves too difficult to implement, another can be chosen without abandoning the whole system. This is particularly important for MRV, as there are trade-offs to be made between two opposing objectives. What seems "best" regarding data quality may qualify as "worst" in terms of feasibility in practice and the potential administrative burden, and vice versa. The proposed working group would gather sufficient expertise to come up with feasible implementation options. Furthermore, a first phase of the CBAM could be used as a learning phase, or more generally, the MRV rules could in general be subject to regular review, taking into account technical progress and improving data availability, if international cooperation on carbon pricing further progresses.

5.2.1 What are "(effective) embedded emissions"?

Firstly, it is important to clarify what "embedded emissions" shall mean in the context of a CBAM. It can be observed in the literature on carbon border adjustments that authors often use a jargon referring to the "carbon content" of products, which should be multiplied by the appropriate carbon price for determining the obligation to be paid under the CBAM. However, as already noted in Section 5.1 (in particular footnote 75), such expressions are misleading. It is not about the carbon physically contained in a product in any chemical state (be it elemental, inorganically or organically bound), but rather about the GHG emissions *released* during production of the material or product subject to the CBAM. Since GHG emissions are expressed as carbon dioxide equivalents (CO_{2e}, calculated by applying the appropriate GWP[82] factors), "carbon" is usually understood as a synonym for these GHG emissions. However, this report uses the term "embedded emissions" as a means to clarify that it is about emissions "carried" through a value chain and hence linked to the product under consideration. Acceptable alternative terms would be "embodied", "linked" or "associated" emissions. The important feature of the term "embedded emissions" is that it is – to our knowledge – currently not used by other legislation or standards. It therefore unmistakable and distinguishable from terms used in the carbon footprint community.

Furthermore, the CBAM is different from other carbon pricing approaches in one important aspect. In order to treat imported goods in an equal manner to goods produced under the EU ETS in terms of carbon costs under Options 1-3, only emissions for which a carbon price is to be paid in the CBAM should be taken into account, if the relevant information is available. This means that any part of the imported goods' emissions for which a carbon price already applied might be excluded from the CBAM obligation, subject to the overall design option chosen[83]. To achieve this, "effective embedded emissions" should be introduced as a concept in calculating the CBAM obligation. The concept would be open to taking into account the carbon price paid already at an earlier stage. The term "a carbon price applied" would reflect any free allocation in case of an ETS, or tax rebates in case of a carbon tax, and would consider also whether the costs of indirect emissions (from electricity consumption) have been compensated in some way.

[82] Global Warming Potentials. In line with current EU legislation, the values given in the 5th assessment report by the IPCC are to be used.

[83] See also section 5.7 on potential interactions with climate policies of third countries.

In summary, we define "embedded emissions" of imported goods as GHG emissions *released* during production of the material or product subject to the CBAM applying specific system boundaries, including emissions from appropriately defined upstream value chains. We define as "effective embedded emissions" those embedded emissions, for which a CBAM obligation has to be paid. The latter may– depending on further design choices – take into account whether for part of the emissions carbon costs have already been paid.

For the purpose of establishing reference default values of the embedded emissions, this report uses the term "embedded emissions" also for production within the EU (i.e. under the EU ETS). For this purpose, total emissions are implied, except in cases where some free allocation or indirect cost compensation would remain in place in the sectors where the CBAM is applied. In such cases (i.e. main Option 2 as discussed in Chapter 3), the reference default values would be reduced by the levels of emissions which are covered by free allocation and the indirect cost compensation.

Note that due to late decision after internal discussions, the distinction between "embedded emissions" and "effective embedded emissions" has been introduced at a late stage in the process. Some more clarification on this concept may be required, and some correction to the report be made. For the final report, further clarification and potentially clearer definitions will be provided.

A generic formula for determining embedded emissions EE_P of a material or product in a value chain can be expressed as follows (without taking into account any carbon price already paid or free allocation received[84]):

Equation (1) $$EE_P = EM_P + IE_P + \sum_{i=1}^{n} MC_i \cdot (EM_i + IE_i)$$

Where EM_P are the direct emissions of the production process of the material or product under consideration, IE_P the indirect emissions of the production process (note that according to MRV options defined in Section 5.2.3 it is possible to omit this parameter). The formula takes into account the emissions of upstream production processes, where the index i indicates the upstream materials 1 to n, and MC_i the amount of material i consumed for one unit of the material or product for which the embedded emissions are to be calculated. EM_i are the direct emissions during the production of material i, and IE_i the respective indirect emissions.

5.2.2 Comparing embedded emissions to product carbon footprints

To complete the picture, it is worth mentioning that there are many initiatives that try to compare emissions at a product level. There are a multitude of approaches because there are a multitude of reasons to ask about which emissions are caused by a product, e.g. to compare different products and to steer consumer behaviour towards more climate and environmentally friendly products. The difficulty, however, is to decide what a product's emissions are, i.e. the main challenge is to define the system boundaries for the initial question. The choices made will have to reflect the purpose of the question. If for example it is about resource efficiency incentives for long-lived products, it can be argued only if the emissions during the use phase are included in the assessment, since long-lived products give lower annual emissions over their lifetime. Similarly, upstream emissions will be relevant if the use of renewable raw materials are of interest.

[84] Variations of the formula *with* carbon costs included (i.e. for calculation "effective embedded emissions") are found in the next section.

One could argue that the product's emissions are "everything that would not be emitted if the product had never been produced". This widest approach ("full carbon or environmental footprint") relates to what is often termed a "cradle to grave" approach of a life cycle assessment. It includes:

- All emissions relating to the mining of raw materials;
- All emissions of materials and intermediate products needed for the manufacture of the product;
- The emissions caused by the production process, including emissions from providing the necessary energy;
- Emissions from transport of raw materials and interim products to the site of the production process;
- Emissions from transport of the product to the consumer;
- Emissions caused during the use phase, for example by energy consumed during the use phase;
- Emissions related to the disposal /end-of-life phase of the product.

However, if focus is given only to the emissions of the production of a product, a so-called partial carbon footprint assessed based on a "cradle-to-gate" approach is more appropriate, including only all the emissions from mining to where the product leaves the production site. Using a "cradle-to-gate" approach means that the last three bullet points above are omitted.

Currently, the most encompassing European approach to determining the environmental impacts during all cradle to grave phases is the "PEF", the Product Environmental Footprint methodology developed by the European Commission[85]. However, this includes many more environmental impact categories than just greenhouse gas emissions and would therefore exceed the needs of a CBAM. The PEF guidance is also very strict with regard to "cut-off"-rules and leaves less flexibility with respect to system boundaries. Partial assessments (e.g. "cradle-to-gate" approach) are only possible for intermediate products. For manufactured products it is not permitted to omit the detailed assessment of upstream and downstream emissions along the value chain, if those emissions would contribute to a significant amount within the product's life. Furthermore, any life cycle assessment of that kind needs specific product-specific rules for setting system boundaries and other implementation details, which are currently published for only a few product categories[86].

Another internationally known and standardised approach is the Carbon footprint of products (CFP), for which a methodological framework is laid down in ISO 14067 ("Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification"). The CFP only focuses on greenhouse gas emissions. It provides also the concept of a partial carbon footprint, which is defined as follows: "*Partial carbon footprint of a product: sum of GHG emissions and GHG removals of one or more selected process(es) in a product system, expressed as CO_2 equivalents and based on the selected stages or processes within the life cycle*". However, this ISO standard would also require further product-specific rules – so-called "Product Category Rules" (PCR) – for making results verifiable and comparable.

All carbon footprint methodologies share the problem that – if strictly applied – knowledge is required about the GHG emissions during all the manufacturing steps and transport stages of all raw materials, energy carriers and upstream production steps (production of intermediate

[85] Commission Recommendation 2013/179/EU on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations, http://data.europa.eu/eli/reco/2013/179/oj.

[86] In the PEF context these are called "Product Environmental Footprint Category Rules (PEFCRs)". Initial results of the pilot phase are found at https://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm.

products). Another fundamental challenge is how to split emissions of a single production step which leads to more than one product, i.e. where by-products should be assigned part of the emissions[87].

To overcome these difficulties in the context of the CBAM, it is useful to recall its purpose: to provide a consistent carbon price to incentivise all the mitigation opportunities while avoiding the risk of carbon leakage. Carbon leakage could result from the fact that the EU ETS puts a price on GHG emissions in a quite specific way, while those costs are not faced in jurisdictions without carbon pricing.

Dependent on the design choice the CBAM mechanism, different approaches to define "embedded emissions" (i.e. the scope of emissions used for determining embedded emissions) may have to be chosen. If the CBAM is applied on imports or imports and exports, the main objective will be to correct for the costs incurred under the EU ETS and potential carbon pricing systems abroad. In this case, **a strong simplification of a partial product carbon footprint needs to be used for determining the relevant "embedded emissions"**. For the purpose of main Options 1 to 3 (see Chapter 3), the following boundaries are appropriate.

- Emissions from upstream operations (mining, transport, etc.) are omitted.

- Upstream production processes in a value chain are relevant only insofar as they are under the EU ETS themselves. However, as it may be difficult to determine emissions of production processes carried out in another operator's installation (or in installations that have no MRV obligations at all), an option should be discussed that does not take into account any upstream processes.

- System boundaries for production steps should be aligned with system boundaries of the EU ETS, e.g. regarding the following.

    - The activities and greenhouse gases to be covered (Annex I of the EU ETS Directive).

    - "Direct emissions" should be covered in the CBAM in the first place, in line with the EU ETS. These include emissions from providing heating (and cooling) even if these are imported from another (adjacent) installation, because these emissions are included in the benchmarks, and because equal treatment of installations with or without own heat supply is achieved this way.

    - "Indirect emissions" (emissions from production of electricity which is consumed in a certain production process) should be included in the "embedded emissions" in principle, in order to make the CBAM the desired effective instrument to mitigate carbon leakage risk also for product groups that have mostly indirect emissions leading to the carbon leakage risk. However, the determination of indirect emissions is not always straightforward, and requires specific rules for how to determine them. Therefore, we define below some options for the implementation of the CBAM, where for practical reasons indirect emissions may be excluded. However, the preferred option is to include indirect emissions.

[87] The carbon footprint term for splitting data according to products is the "allocation method". Note however that throughout this report "allocation" is used exclusively within the meaning of the EU ETS, i.e. allocation of allowances. For assigning emissions to different products, the EU ETS free allocation rules use the term "attributed emissions".

Downstream emissions are omitted, i.e. no emission from the use phase or disposal (or recycling[88]).

Within the context of CBAM Option 4 (excise in combination with the EU ETS), the embedded emissions to be considered for the determination of the excise may, in principle, also comprise emissions from upstream operations (mining, transport, etc.) and downstream emissions, e.g. from disposal (or recycling).

Note that embedded emissions also include production steps performed outside the EU. Therefore, "being under the EU ETS" in the context of non-EU production should be read as "would be covered by the EU ETS, if the installation were situated in the EU". Furthermore, the terminology "direct" and "indirect emissions" are used in the sense they are used in the EU ETS, although it must be mentioned that other uses of these terms are common in the literature as well[89].

Regarding value chains, it must be noted that it is at the core of carbon footprint determination to go beyond the monitoring of just one production step. Hence, while in the EU ETS it would be perfectly possible to consider only the steelmaking per se as an emitting process (benchmark "hot metal"), a product carbon footprint of the steel would clearly aim at also including the emissions caused by the production of the coke, lime and sinter which all are required to produce steel. No matter which approach is chosen, it is essential that for each product the MRV boundaries are clearly defined, i.e. if production steps upstream of the considered product are to be considered, and which ones. In the example of steel, it would have to be defined whether only the boundaries of the hot metal benchmark are to be included, or also the upstream production of coke and sinter, and whether minor contributions such as lime and scrap, for instance, need also to be taken into account. This would have to be part of MRV rules yet to be defined.

In the chapter on the potential scope (Chapter 4, more specifically Section 4.4 on value chain considerations) it was assumed that it should be possible to take into account some more or less well-defined value chains for the production of basic materials and products. However, it will be a challenge to gather all data needed to define default values for embedded emissions, and the monitoring and reporting requirements may be hard to fulfil. Therefore, it is suggested to keep it open at this point to what extent value chains should be taken into account for embedded emissions for CBAM purposes.

Taking into account carbon costs already paid: in Section 5.2.1 it was stated that (depending on the CBAM's implementation design), "relevant" or "effective" embedded emissions for CBAM should only include emissions for which no carbon price applied, or for which the carbon price was lower than under the EU ETS. This would only be relevant for embedded emissions of imported goods, not for the determination of reference default values in the EU, which would then apply to calculate the CBAM obligation.

The carbon costs of a material occurring in a single production step in a carbon pricing system can be expressed as follows:

Equation (2): $CC = P \cdot (EM - FA) + IC - ICC$

[88] Recycling would be the start of a new production process, for instance in the metals industries, where scrap would be considered a raw material for a specific production process.

[89] In particular, there is a wide use of the "Scope 1, 2 and 3" emissions of the GHG protocol by the WBCSD (https://ghgprotocol.org/) elsewhere, but given the need to make comparisons with the EU ETS, other such classifications are not suitable and would be confusing for the purposes of the present report.

Where *CC* are the carbon costs for one unit (e.g. a tonne) of the material, *P* is the price for one unit of emissions (an allowance), *EM* the emissions attributed to that production process using applicable MRV rules, *FA* the level of free allocation granted per unit of production, *IC* the indirect costs from electricity consumption per unit, and *ICC* the indirect cost compensation level per unit, if applicable. If this equation is modified by dividing by the carbon price, it gives an expression for the effective embedded emissions (*EEE*) required for the CBAM:

Equation (3): $EEE = EM - FA + (IC - ICC)/P$

Applied to a value chain and taking into account several production steps, the final effective embedded emissions could be calculated as follows:

Equation (4): $EEE = \sum_{i=1}^{n} MC_i \cdot [EM_i - FA_i - (IC_i - ICC_i)/P]$

In this case the index *i* indicates the materials 1 to *n*, and MC_i the amount of material *i* consumed for one unit of the material or product for which the embedded emissions are to be calculated. EM_i are the emissions during the production of material *i*, etc.

Using this definition of effective embedded emission, the calculation of the CBAM obligation is simple. In case of an import tax (Option Pay.3, see Section 5.4.1), the obligation would be:

Equation (5): $O_{tax} = IM \cdot EEE \cdot P_{ref}$

Where O_{tax} is the CBAM obligation if expressed as a tax (in euro), *IM* is the imported mass of the material or product, *EE* the embedded emissions, and P_{ref} the reference price for emissions to be applied (for options see Section 5.1).

If the CBAM obligation has to be expressed as number of notional or EU ETS allowances, the following equation would apply:

Equation (6): $O_{allow} = IM \cdot EEE$

Where O_{allow} is the CBAM obligation expressed as number of allowances.

Note however, that Equation 3 applies to the most encompassing approach to effective embedded emissions used in this report. Depending on design options to be chosen for the actual CBAM design, some of the parameters can be omitted. This will be discussed in Section 5.2.3. On the other hand, the given approach makes it possible to take into account carbon pricing systems outside the EU and whether products cross the EU several times throughout a value chain. To achieve this, the carbon costs already faced would be included in the emission reports of the non-EU operators (see Sections 5.2.6 and 5.2.7) and would be verified together with the emissions. Hence, there would be no need to explicitly treat countries differently. All the necessary implementation issues would be just part of the CBAM's MRV rules and hence equally applicable to all third countries.

5.2.3 Implementation options for defining effective embedded emissions

There are several possibilities to define embedded emissions and "effective embedded emissions" (the latter being directly applicable in calculating the CBAM obligation). This definition is crucial for the whole CBAM design for three reasons: Firstly, it has a very strong impact on the necessary MRV provisions and thereby on the administrative complexities and related costs. Secondly, it defines the scope of emissions covered and thereby influences the environmental effectiveness of the CBAM. The impact will be greatest if value chains and indirect emissions are taken into account, while the impact will be quite limited if embedded emissions are defined more narrowly, so that the CBAM obligation would be calculated based on only part of the emissions actually caused by imported goods. Finally, the definition of embedded emissions could even solve the issue of whether third countries' own climate policies (in particular their carbon pricing systems in place) can be taken into account: If the carbon costs already paid are reported and verified together with the emissions, this information could be used without adding other provisions to the CBAM design for that purpose.

Hence, there are three factors (each with two possibilities) which can be used to differentiate options to define "effective embedded emissions", as follows.

- Factor EE.CC: Are Carbon Costs taken into account?
  - Option EE.CC.1: Carbon costs paid outside the EU are taken into account in the determination of the effective embedded emissions / CBAM obligation.
  - Option EE.CC.2: Those costs already paid are not taken into account. (Effective embedded emissions are identical to effective emissions in the purely technical sense). This would lead to higher CBAM obligations, but it could be considered as unfairly discriminating goods produced in countries that have useful climate policies in place. Therefore, additional design elements would probably be needed to take these policies into account, for instance, by explicitly differentiating default emission values by country. This could be disputed, and finding appropriate default values could prove to be difficult.
- Factor EE.VC: Is the Value Chain (upstream) being taken into account?
  - Option EE.VC.1: The value chain is taken into account, i.e. embedded emissions of materials used to produce the imported good would be added to the emissions of the production process that leads to the good imported.
  - Option EE.VC.2: Only the emissions of the final production step (more or less similar to emissions of a single product benchmark sub-installation in the EU ETS) are used as embedded emissions and for defining the CBAM obligation. In the case of polymers, for instance, only the emissions of the polymer (e.g. PE, PP, PVC) would be taken into account, but the emissions caused by the cracker process for producing the monomer would be excluded, although it causes the biggest share of emissions required to make polymers. This option would lead to significantly lower CBAM obligations, less environmental effectiveness, and significantly lower revenues from the CBAM.
- Factor EE.IE: Are Indirect Emissions (i.e. emissions from production of the electricity consumed) taken into account?
  - Option EE.IE.1: Indirect emissions are taken into account. Although a few methodological issues need to be solved (how to best determine the emission factor of the power grid's energy mix), this option is clearly preferred, as it gives a better correlation to the factors influencing carbon leakage.
  - Option EE.IE.2: Indirect emissions are not taken into account. Note that this option would have a significant impact on the potential scope of the CBAM (i.e. the products to be covered), because the carbon leakage risk caused by indirect emissions costs could not be mitigated. Several products discussed in Chapter 4 and proposed for inclusion in Section 4.6 would become irrelevant for the CBAM. Most prominently, aluminium products and other non-ferrous metals as well as

chlorine-based chemicals (including PVC) would have to be removed from the scope of the proposed CBAM.

Note that factors EE.VC and EE.IE can apply to both embedded emissions and effective embedded emissions.

This gives a total of eight combinations of embedded emissions options, with Option 1 being the most encompassing and ambitious, and Option 8 the simplest, but least effective regarding its environmental effect (i.e. regarding its potential to mitigate the risk of carbon leakage):

Table 5-1: Possible options to define "embedded emissions"

Option Number	Factor EE.CC (Carbon costs taken into account?)	Factor EE.VC (Value chain taken into account?)	Factor EE.IE (indirect costs taken into account?)
EE.1	1 (yes)	1 (yes)	1 (yes)
EE.2	1 (yes)	1 (yes)	2 (no)
EE.3	1 (yes)	2 (no)	1 (yes)
EE.4	1 (yes)	2 (no)	2 (no)
EE.5	2 (no)	1 (yes)	1 (yes)
EE.6	2 (no)	1 (yes)	2 (no)
EE.7	2 (no)	2 (no)	1 (yes)
EE.8	2 (no)	2 (no)	2 (no)

The preferred option in terms of environmental effectiveness and general climate ambition is EE.1. However, it is the most challenging in terms of MRV requirements and administrative burden. This is in line with the assumption given in the introduction of Section 5.2, where we propose that the CBAM design should be comprehensive in terms of embedded emissions definition and the associated MRV system. Following this assumption, there should be an expert group established to work on further details. If Option EE.1 appears infeasible in discussions of that group, less ambitious options should be chosen. Alternatively, to achieve the best possible CBAM design, it could start with a less ambitious design for a testing phase, and based on practical experience gained, a more ambitious setup could be chosen for following periods.

Consequently, Option EE.1 forms the basis for the following sections. It is to be added, however, that this preference for Option EE.1 strongly depends on the depth of the value chain that is to be included for the CBAM. The assumption for the whole of Section 5.2 is that one of the main Options 1 to 3 will be applied, i.e. a form of "payment" (as a tax, or as surrender of notional or EU ETS allowances) for imported goods will be required. Option 4 (excise) may allow or require other approaches (see Section 5.6). Furthermore, it is assumed that the conclusions on the possible scope of the CBAM (see Section 4.6) apply, i.e. that basic materials, basic material products, and potentially some semi-finished products would be included in the CBAM (including several which are carbon leakage exposed due to indirect emissions), but no manufactured products (for definitions see Section 4.4.1).

In the case of main Option 4 (excise), embedded emissions could be based fully on *estimates* of EU internal data (no need to gather non-EU data), but more tracing of the composition data of goods throughout the value chain would be required. For Option 4, the excise would be defined independently of where the good has been produced. Consequently, Options EE.1 to EE.4 would not apply.

In the case of main Option 5 (carbon added tax), it would be assumed that full value chains down to the final customer would have to be traced. In the terminology of product carbon footprint, a cradle-to-gate approach of final products would be required, but only in the form of a partial carbon footprint, taking into account only the production steps covered by the EU ETS , as explained above. It is hard to imagine that this would be done by producers of the final products unless a kind of EU-wide database for embedded emissions were set up that *would have to be filled mandatorily by all producers involved*. This is hardly feasible within a reasonable timeframe, because most of the manufacturing industry has not had any such emission monitoring obligations in the past. Only some manufacturers who have environmental management systems in place may have some emissions data available, but usually not broken down to product level.

5.2.4 What needs to be monitored, reported and verified in order to determine embedded emissions?

As has been often observed in the context of carbon pricing, MRV, i.e. the Monitoring, Reporting and Verification of emissions are the cornerstones of any such system. Without robust MRV, stakeholders would not trust the system. As everywhere in the financial world, it is of utmost importance to get robust, reliable numbers matching reality as closely as possible. In the ETS community this is usually summarised as "a tonne (reported) must be a tonne (emitted)".

In this section we discuss which data are required to determine a product's embedded emissions. We also explore what legislation there is for what data in the EU, i.e. what monitoring and reporting rules already exist. The monitoring inside the EU is meant to support the determination of any default values required to determine the embedded emissions of imported goods. This process will be described in Section 5.2.5. Following on from this, in Section 5.2.6, we consider how non-EU producers could provide their data on a similar basis in order to indicate the embedded emissions of their products.

Figure 5-1 shows the monitoring requirements at the level of a single installation, which produces two groups of semi-finished products, where each group is relatively similar regarding the embedded emissions of the related products (i.e. all the slabs have similar embedded emissions, and all the triangular items are comparable amongst each other). The arrows indicate the quantity measurements required, and the red frames highlight where knowledge of embedded emissions would be required. In this example the following information can be derived.

The direct emissions of the installation have to be monitored[90] under the MRR (the Monitoring and Reporting Regulation for the EU ETS).

- The quantities of all fuels and raw materials entering the process are also usually monitored under the MRR. However, if a material does not contribute to the emissions, there is no need to monitor it under the MRR. In the figure, this is shown by a dashed green arrow for a basic material needed for the process. If this material carries relevant embedded emissions, its quantities would have to be monitored.

- The amounts of heat imported to or exported from the installation have to be monitored under the FAR (Free Allocation Rules Regulation), as it is relevant for determining free allocation levels. However, the emission factor related to imported heat (i.e. the embedded emissions of heat) is not to be reported mandatorily, because it is sometimes unknown.

[90] To learn more about the concepts and approaches in the EU ETS, there is a wide range of guidance materials available from the European Commission's website, including "Quick guides" for different interested parties. See https://ec.europa.eu/clima/policies/ets/monitoring_en#tab-0-1 for details. A good entry point for the interested reader is Guidance Document No.1 ("The Monitoring and Reporting Regulation – General guidance for installations"): https://ec.europa.eu/clima/sites/clima/files/ets/monitoring/docs/gd1_guidance_installations_en.pdf.

Therefore, the CBAM rules would require additional rules for making estimates or for requiring heat suppliers to provide the missing information.

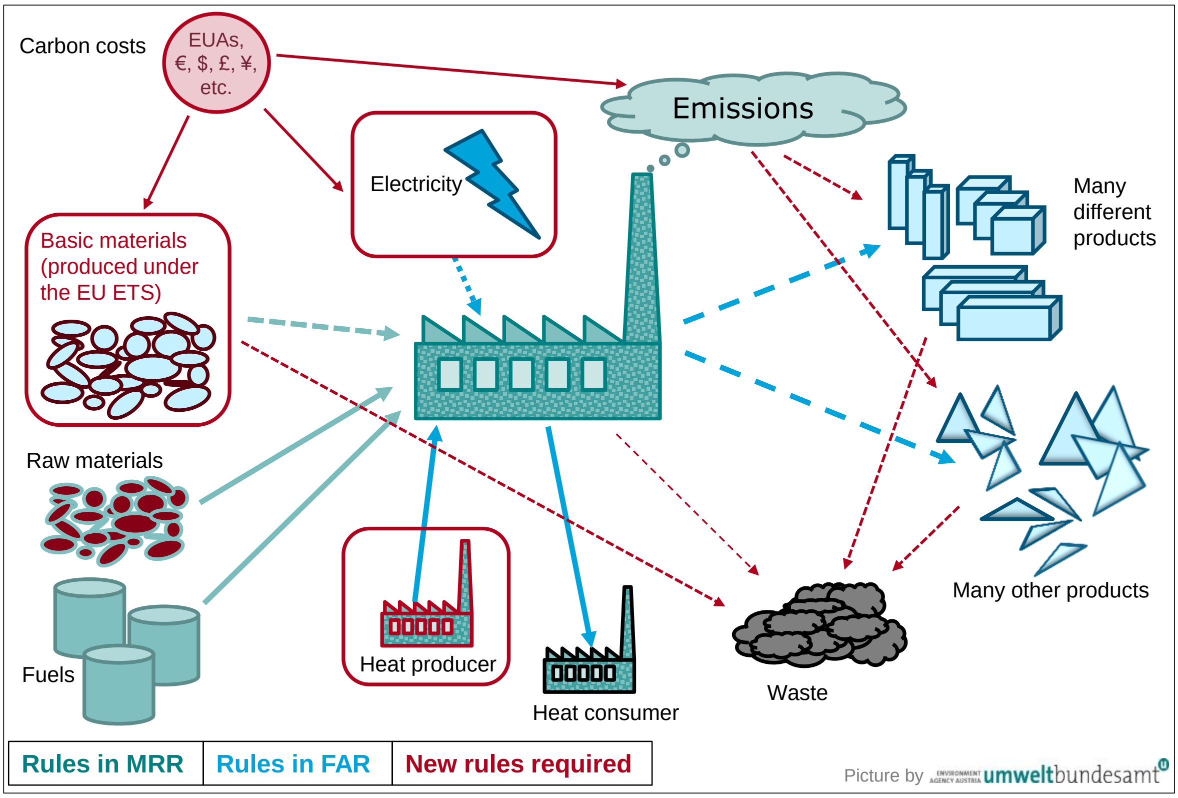

Figure 5-1: Overview of existing and additionally required data needs for determining embedded emissions of a relatively simple production process.

- Regarding the quantity of electricity consumed at the installation, there is currently no mandatory reporting, except in some selected cases (where exchangeability of electricity and fuels applies to a product benchmark).

- In any case, there is no rule yet for determining the applicable emission factor (the embedded emissions) of electricity consumed. Note that additional rules will be needed where "guarantee of origin" (GoOs) systems are in place. If an EU ETS operator claims the use of renewable (or other CO_2 free) electricity by using GoOs, it must be ensured that the same GoOs cannot be claimed by somebody else, and the residual electricity mix must be adjusted accordingly for its average emission factor[91].
  In the absence of more detailed rules, it could be envisaged that a tiered approach, as for most other monitored parameters, could be proposed. The highest or "best" tier would be the actual emission factor of the electricity consumed, where there is a direct physical link and a contract for receiving electricity from specific power plants, or where GoOs are claimed, provided that the emission factor of the residual power mix is adjusted accordingly. The other possibility would be the use of a national grid's power mix (in some countries this is available in near to real-time, but an annual average would be sufficient).

[91] While this will most likely function smoothly within most EU Member States, a similar requirement would have to be applied for non-EU producers who declare their products' embedded emissions. It is expected that not all the exporting countries have such well-documented electricity grid data available.

- Regarding the quantities of the products of the installation, the FAR require only monitoring of the aggregated amounts of products which together form the "activity level" of product benchmark "sub-installations". While these will often be sufficiently correlated to CBAM product groups, there are several important cases where the benchmark is not directly linked to production levels of products, in particular in the refinery and chemicals sectors. Some associated issues are discussed in Section 4.4. Consequently, the blue arrows in the figure are dashed. Additional rules will clearly have to be developed.

- More generally, there will also have to be rules for monitoring of product quantities that need to be differentiated within one single "sub-installation"[92], in particular if the products do not fall under product benchmarks in the EU ETS. In the latter situation allocation can be granted using the so-called fallback sub-installations (based on heat amounts or fuels consumed, the latter for "non-measurable heat"), or for process emissions not otherwise covered. At the current stage the reporting for disaggregated product quantities is mostly voluntary, except in cases where the operator wants to claim energy efficiency improvements for heat or fuel sub-installations[93]. For CBAM purposes, it would be useful to make this more disaggregated reporting mandatory. Otherwise several embedded emission values would have to be determined based on estimations.

- Even if the reporting of disaggregated product quantities were regulated, rules would still be missing for attributing the emissions of the installation to those disaggregated products. Currently, the FAR provide these attribution rules only for sub-installations. In principle the same rules could be applied in a similar manner to the disaggregated level. However, the monitoring efforts required would be a multiple of current efforts, and operators would possibly oppose such additional requirements.

- Similar to emissions, quantities of input materials might also have to be attributed to the different products of the installation. This can be restricted, however, to inputs that have assigned embedded emissions, e.g. if coming from another EU ETS process. It might also be necessary to consider waste streams, if the waste amounts are relevant for deciding to which product the emissions embedded in waste should be assigned.

- The potentially biggest missing element is the lack of any requirement to report the embedded emissions of inputs into the production process. This includes all basic materials, basic material products or semi-finished (or even finished) products required in the process. It is also relevant for the embedded emissions of the energy inputs (heating, cooling, electricity), although, as mentioned, for these several cases are already covered by the FAR. There is an issue because the monitoring of the embedded emissions is outside the competence of the operator of the installation shown in Figure 5-1. The operator would depend on the good will of the suppliers of these materials to provide sufficiently robust (verified) data in this regard, unless a separate legal MRV requirement would be provided for installations not covered by the EU ETS themselves[94].

[92] The term "sub-installation" defines system boundaries for emissions, materials and energy flows which relate to one product benchmark or fall-back approach. For more information, please consult the Commission's guidance documents for free allocation, in particular Guidance Document No. 5 ("Guidance on Monitoring and Reporting in Relation to the Free Allocation Rules")
https://ec.europa.eu/clima/sites/clima/files/ets/allowances/docs/p4_gd5_mr_guidance_en.pdf

[93] This is regulated in the Allocation Level Change Regulation (ALC Regulation), which together with the FAR regulate the annual reporting of data needed to update allocation in case of significant activity level changes.

[94] This could be, for instance, the mandatory reporting of embedded emissions for all EU manufacturers with the aim of setting up a complete carbon footprint information data base, if a policy instrument required complete product carbon footprint data.

- Finally, as discussed in Sections 5.2.1 to 5.2.3, effective embedded emissions may refer only to the emissions that are not facing similar carbon costs as under the EU ETS. Therefore, some relevant information on carbon costs in other countries would have to be part of the MRV system. For determining the embedded emissions in a CBAM design where EE.CC.1 applies (see 5.2.3), an emissions report would have to contain information on an applicable carbon price (e.g. the previous year's average price) and how it has been determined, the amount of allowances received for free, if applicable, and information on any compensation received for indirect carbon costs, if applicable. Those cost data would then have to be attributed to the different products of the site in a similar manner as the emissions. The verifier would have to verify this information as part of the emissions report.

So, in short, the situation is that EU ETS legislation (MRR, FAR, ALC) covers many data requirements, but not at sufficient disaggregation level for many potential candidate product groups proposed for the CBAM's scope (see Section 4.5). More legislation will be required, in particular for all the cases where value chains need to be covered, i.e. where a producer requires data from one or more other producer(s), who in turn perhaps need further data from other even more upstream producers, it will be difficult to ensure the completeness and correctness of data[95]. However, it is to be noted that all these additional requirements would serve purposes which are not in the direct interest of the EU ETS installations' operators, and may therefore face opposition when the legislation is developed.

- Some of the additional data is required to determine reference default values of embedded emissions of the products covered by the CBAM (see Section 5.2.5).

- Some of the additional MRV rules apply to value chains, in particular regarding the treatment of embedded emissions of materials purchased for use in the production process. Those rules would be the blueprint for rules applicable to imports from non-EU producers. For operators in the EU ETS, such rules are only required if MRV.Def.1 applies (see Section 5.2.5). Secondly, such rules are not required if the CBAM design does not allow importers to demonstrate actual emissions, i.e. if only default values are allowed. Such "value chain MRV rules" are furthermore not required if Option EE.VC.1 is used for the determination of embedded emissions (see Section 5.2.3). We can thus define two options, as follows.

    - Option MRV.VC.1: There is a requirement for producers of CBAM-covered products to determine and report embedded emissions of relevant input materials to determine the embedded emissions of their products taking into account value chains. A list of all relevant input products could be drawn up in an implementing act (such as the CBAM scope itself). This option is compatible with Option EE.VC.1 (See Section 5.2.3).

    - Option MRV.VC.2: No requirement to determine the embedded emissions of the upstream production steps in the value chain. If any upstream emissions were to be included, they would be determined based on default values only. Compatible with Option EE.VC.2.

[95] This finding is based on the experience of EU ETS monitoring. Operators often rely on data from laboratory analyses of the suppliers (e.g. regarding the net calorific value and carbon content of fuels), but these data are not regularly provided. In some cases it helps to include provisions in the purchase contracts on an obligation to deliver such data, but there are many cases where EU ETS operators still have to rely on default values given in the MRR or in the national GHG inventory.

- In a similar way, MRV design options could be defined which reflect the other factors needed for defining the embedded emissions (see Section 5.2.3). These options would be as follows.
    - Option MRV.CC.1: There is an obligation to provide information on the applicable carbon price, free allocation received and indirect cost compensation, where applicable.
    - Option MRV.CC.2: No such information has to be provided.
    - Option MRV.IE.1: Indirect carbon costs have to be reported, i.e. the quantity of electricity consumed and the applicable emission factor of electricity.
    - Option MRV.IE.2: No such information is to be reported.

5.2.5 How to determine default values of embedded emissions?

There are, in principle, two options for determining default values of embedded emissions of the products covered by the CBAM.

- Option MRV.Def.1: Default values are to be determined by data collection, similar to the EU ETS benchmarks, based on legal requirements for EU ETS installations, or even by requirements applicable to all industry sectors affected in some way by the CBAM.
- Option MRV.Def.2: Default values are determined by other means, such as literature studies, expert judgement, stakeholder contributions, BREF documents, etc., supplemented by EU ETS data wherever possible.

Notably, default values can be required not only for embedded emissions of the products listed for the scope of the CBAM, but also for smaller parts within the related value chains, such as consumption factors of precursor materials or their embedded emissions. Also, for electricity and heat it might be required to determine default emission factors.

A key principle for the definition of reference values will have to be defined already at the design stage of the CBAM, while the definition of the actual values can take place later and should be regularly updated. The key principle would therefore be whether the reference values should be aligned with EU ETS benchmarks, which are set according to the 10% best installations in the EU ETS, or with another measure such as the EU (weighted) average, median or other approach. Notably, the EU ETS benchmarks would lack ambition for the purpose of a CBAM and would rarely incentivise importers to provide actual emissions data of the imported goods. Furthermore, low values like the EU ETS would not provide very strong carbon leakage protection.

The default values could also be based on more international data, if available. For example, if international working groups were established to jointly design climate mitigation measures or to cooperate on linking emission trading systems, actual emissions data from other jurisdictions could also be included in the data collection.

Option MRV.Def.1 would require monitoring and reporting of significant amounts of data which are not required for EU ETS purposes, and which may be hard to determine in any event (i.e. even the MRV rules may have to refer to fallback options, estimates, or reference values from the literature). Additional MRV legislation as mentioned in Section 5.2.4 would have to be put in place, including how data would be collected at Member State level and forwarded to the Commission for relevant checks (similar to EU ETS benchmarks). Hence, this approach would be onerous. And while it is, in principle, a desirable approach, since the data would be less disputable if based on actual data, it will be questioned whether these efforts add sufficient value to the CBAM design in relation to the additional administrative burden.

Option MRV.Def.2 seems more feasible, although the resulting default values may be more susceptible to challenge by stakeholders (both inside and outside the EU). However, the better the data collection under this option, and the more transparent the decision-making on final values, the more can this risk be limited. It would help acceptance of the default values determined if they are agreed by the appropriate forum, e.g. a technical working group of Member States. For option MRV.Def.2, no new monitoring obligations would have to be introduced for EU ETS operators. Any new MRV rules (if any), would only apply to the determination of embedded emissions of imported goods.

5.2.6 How can a CBAM importer use actual emissions data from a non-EU producer?

In a perfect world, climate mitigation-wise, where all countries operate carbon pricing systems for reducing industrial GHG emissions (where perhaps even all the emission trading systems would be linked), all the installations covered would monitor and report their emissions in a more or less comparable way, and equally competent verifiers would testify that the emission reports are correct at a similar level. Operators of installations around the world would be supervised by competent authorities under each country’s jurisdiction, compliance checking and enforcement of penalties would be clearly the competence of each country. Since everything would be mandatory, there would not be a problem if the MRV rules required that data on embedded emissions be forwarded to the buyer of any goods, who in turn needs this data to determine their own products’ embedded emissions. Determining cradle-to-gate product carbon footprints would not be too difficult.

Obviously, this is not a perfect world, and the CBAM design has to take into account that any regulation would be mandatory only for the actors inside the EU. Consequently, when it comes to defining the amount of embedded emissions of a good imported into the EU, it is not proposed to have an option “actual emissions must be demonstrated”. Only the following two options are defined.

- Option DV.1: Only default values are used for embedded emissions of imported goods (referred to as main Option 1a in Chapter 3, but similar sub-options are possible for main Options 2 and 3 as well).

- Option DV.2: When actual embedded emissions are unknown or not provided[96], the default values determined at EU level (see Section 5.2.5) are used. However, the importer may use actual emission figures obtained from the producer of the imported good, provided they are determined following MRV rules defined as part of the CBAM legislation (referred to as main Option 1b in Chapter 3).

Notably, Option DV.2 would be voluntary. No operator of an installation outside the EU would be obliged to monitor and report their emissions. However, since detailed emission reporting rules in various carbon pricing instruments are quite different regarding their technical details[97], it would be crucial for making data quality comparable for all possible CBAM imports. For this purpose, the

[96] It is assumed that non-EU operators would not usually report their emissions if they are higher than the EU default value, as this would lead to a higher CBAM obligation to be paid. It is therefore not explicitly necessary to forbid the use of actual emissions if they are higher than the default values.

[97] As can be seen for example in the PMR publication “Developing Emissions Quantification Protocols for Carbon Pricing: A Guide to Options and Choices for Policy Makers”: https://openknowledge.worldbank.org/handle/10986/34388.

CBAM should require that minimum rules defined for this purpose have to be followed. They would be largely in line with the EU ETS (including any necessary additional legislation not yet in place, see Section 5.2.4). To the extent feasible, the rules could be made more "international" by using references to ISO standards wherever they are sufficiently in line with EU ETS / CBAM requirements. Furthermore, it would be useful (but not necessary) to establish a forum of international cooperation between the EU and interested countries, who want to provide data contributing to the development of default values, or who are working on establishing an MRV system and/or carbon pricing instrument in their jurisdiction. Such a forum could provide for mutual learning as well as making the applicable MRV rules as fit for the CBAM purpose as possible, based on best practice experience in the involved countries.

An outline for the practical implementation of Option DV.2 could be as follows (it is the basis for the European part of the CBAM further elaborated in Section 5.8):

- In order to have a similar instrument as the monitoring plan in the EU ETS (which has to be approved by the competent authority (CA) and thereby prevents arbitrary choice of monitoring approaches), the non-EU operator would be required to have a documented and site-specific monitoring methodology in place. Where there is no mandatory carbon pricing system in place which would facilitate an approval by a CA, an independent verifier would validate the methodology which would henceforth be followed. This approach is similar to Clean Development Mechanism[98] (CDM) projects and is therefore considered feasible in principle, although the complexity of the required monitoring may be greater for the CBAM.

- The reporting period should be a year. Shorter periods tend too easily to include non-representative periods, e.g. times of unusual capacity utilisation. Longer periods may lead to problems if errors remain undetected and are thus extended over time. Note, however, that the reporting does not have to coincide with a calendar year as in the EU ETS. If the country has a carbon pricing system with other compliance dates in place, they should be used for keeping the administrative burden low. Furthermore, it would be beneficial for the balancing of European CAs' workload, when they have to check emission reports used for the CBAM (see Section 5.2.7).

- The operator of the non-EU installation would provide annual emission reports containing information not only about the whole installation's emissions and production levels, but also the embedded emissions at a level of disaggregation required for use in the CBAM.

- An independent verifier would verify the emission reports, applying the principles and rules laid down in the AVR for the EU ETS, and – if applicable – further international standards for verification in the area of GHG monitoring and (partial) product carbon footprints.

- In order to ensure the qualification and competence of verifiers, accreditation of the verifier by a European National Accreditation Body (NAB) in line with the AVR's requirements would be mandatory.

- The emission report (if positively verified) would then be registered and made available[99] in a European database (termed "CBAM facility" in Section 5.4.1). A CA in one of the EU Member States (or at the EU level, see Section 5.4.1) would check the emission report (or

[98] The CDM is a mechanism under the Kyoto Protocol, managed by the United Nations Framework Convention on Climate Change (UNFCCC) https://cdm.unfccc.int/index.html.

[99] Translation into one of the EU's official languages would be required.

if there are too many, a sample of reports would be checked). If there are problems found, the CA would have to contact verifier and/or the operator in order to get the report corrected.

- If the CA is satisfied with the report, it would be marked as compliant, and CBAM importers can henceforth use the embedded emissions given in that report, if proof is provided that the imported goods originate from that installation.

- Notably, this database/CA check approach would allow many importers to use the same installation's data without having to pay for verification for each separate import. The costs for monitoring and verification are assumed to be borne by the operator of the installation, who would recover the cost by charging the importers, and who might still benefit from importing goods with lower emissions than the default embedded emissions.

- The embedded emissions determined on the basis of this emission report would remain valid for a year, until a new verified emission report is registered. If no new report arrives (potentially after some grace period after that year), the embedded emissions data would expire, and the importer would have to apply the EU default values again.

- Provided that the CBAM's MRV rules apply Option EE.VC.1 / MRV.CC.1 (i.e. upstream emission in the value chain are to be included in the embedded emissions data, see Sections 5.2.3 and 5.2.4) the emission report of the non-EU installation would have to include the embedded emissions of the materials and products used in the production process. Since it is expected that this may be difficult and expensive (all operators producing those precursor materials would have to follow the same MRV approach given here), the use of default values for those upstream products should be allowed. However, this principle would also be applicable if goods produced in the EU were exported, used in further production processes outside the EU and re-imported to the EU. The carbon costs already faced once in the EU ETS could be deducted from the CBAM for the re-imported good.

- If the CBAM's MRV rules apply Options EE.IE.1 / MRV.IE.1 (i.e. including indirect emissions from electricity production in the embedded emissions data, see Sections 5.2.3 and 5.2.4), respective MRV rules need to be followed for electricity consumption.

- If the CBAM's MRV rules apply Options EE.CC.1 / MRV.CC.1 (i.e. including already paid carbon costs in the embedded emissions data, see Sections 5.2.3 and 5.2.4), the relevant cost-related information must be included in the emission report, verified, and ultimately checked for plausibility by the CA in the reconciliation process.

5.2.7 How can a "CBAM compliance cycle" work?

In Sections 5.4.1 to 5.4.4 practical implementation proposals are made for the CBAM. There, two major approaches are described: Option Cycle.1 relies on immediate payment of the CBAM obligation, while Option Cycle.2 requires a kind of (annual) data reconciliation. Option Cycle.2 is inspired by the EU ETS's "compliance cycle". This compliance cycle is shown in Figure 5-2. There is the compliance cycle in its general meaning (annual throughout the year, once a year verification and reporting to the CA and surrender of the relevant amount of allowances for achieving compliance), and there is the "wider compliance cycle" where verification findings can lead to required improvements of the monitoring plan. The timing of the EU ETS compliance cycle is given in Table 5-2.

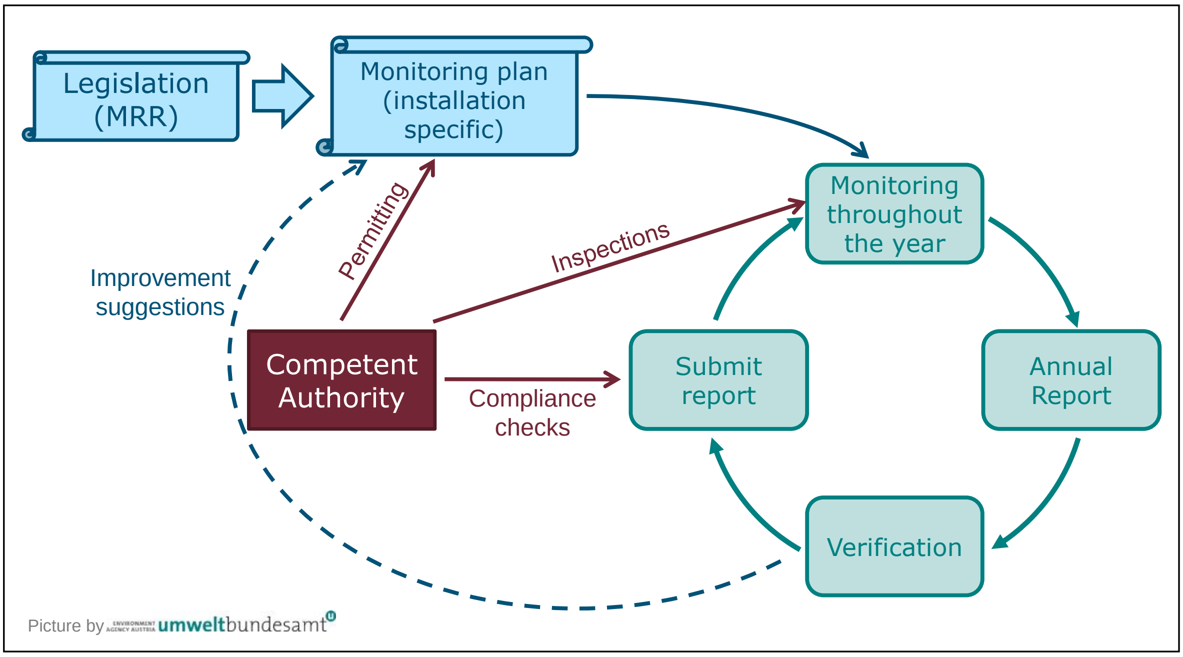

Figure 5-2: Principle of the EU ETS compliance cycle for the annual emissions MRV (Source: European Commission's MRR guidance document No.1[100])

Table 5-2: Common timeline of the annual EU ETS compliance cycle for emissions in year N. (Source: MRR guidance document No.1).

When?	Who?	What?
1 January N		Start of monitoring period.
By 28 February N	CA	Allocation of allowances for free (if applicable) on the operator's account in the Registry.
31 December N		End of monitoring period.
by 31 March N+1	Verifier	Finish verification and issue verification report to operator.
By 31 March N+1	Operator	Submit *verified* annual emissions report.
By 31 March N+1	Operator / Verifier	Enter verified emissions figure in the verified emissions table of the Registry.
March – April N+1	CA	Subject to national legislation, possible spot checks of submitted annual emissions reports. Require corrections by operator, if applicable. NB Subject to national legislation, there is no obligation for CAs to provide assistance or acceptance of operator reports either before or after 30 April.
By 30 April N+1	Operator	Surrender allowances (amount corresponding to verified annual emissions) in Registry system.
By 30 June N+1	Operator	Submit report on possible improvements of the MP, if applicable.

[100] https://ec.europa.eu/clima/sites/clima/files/ets/monitoring/docs/gd1_guidance_installations_en.pdf.

When?	Who?	What?
(No specified deadline)	CA	Carry out further checks on submitted annual emissions reports, where considered necessary or as may be required by national legislation; require changes of the emissions data and surrender of additional allowances, if applicable (in accordance with Member State legislation).

For a CBAM with Option Cycle.2, the "CBAM compliance cycle" could be defined as follows.

- There is no need for a monitoring plan, as the whole system would depend extensively on data in a single electronic registration database, called the "CBAM facility" (see Section 5.4.1). However, it is necessary for every CBAM importer to be registered in the CBAM facility. It is furthermore advisable that some "know your customer" checks would be performed during the registration in order to reduce risks of fraud.

- Instead of operators monitoring their emissions, CBAM importers collect data on their imports, i.e. the type and quantity of the imported goods, and their embedded emissions. If Option DV.1 (only default values) applies, no further information is required. If Option DV.2 applies, and the importer wishes to use actual data of embedded emissions, a reference to the applicable emissions report registered in the CBAM facility is required.

- The import data are collected for a full year, with the deadlines fixed in the CBAM design. Then the "**reconciliation**" takes place: All imported goods quantities multiplied by their embedded emissions are added up to give the emissions for which an obligation under the CBAM is to be "paid". In the case of an import tax, the result has to be multiplied by the reference allowance carbon price (see Section 5.1) and the appropriate amount be paid to the CBAM authority. In case of surrender of either EU ETS allowances or notional allowances, the appropriate amount of allowances needs to be surrendered.
  The calculation for the reconciliation can either be carried out by the importer itself or (preferably) by the competent authority. In most cases, the calculation would be carried out automatically by the CBAM facility, but the CA should still have the opportunity to check and correct data where necessary, e.g. if during the reconciliation period information has become available that emission reports regarding embedded emissions were incorrect, or that customs authorities have discovered incorrectly declared imported goods, etc.

- **Deadlines**. As outlined in Section 5.2.6, embedded emissions data of non-EU operators should be valid for one year after acceptance by a European competent authority. Depending on the timing design of the CBAM compliance cycle, three options would be possible for when the monitored emissions apply.

  - Option MRV.Ap.1: The emissions data apply retrospectively to imports produced during the period when the emissions have been monitored.

  - Option MRV.Ap.2: The embedded emission values apply to imports cleared the year after acceptance of the emission report.

  - Option MRV.Ap.3: The embedded emission values apply to all imports of the ongoing "reconciliation period".

  Option MRV.Ap.1 would have the disadvantage that the importer would have to wait possibly much longer than a year until the CBAM obligation can be calculated. Option MRV.Ap.2 is clearly simpler to apply, although it is less precise: If an operator demonstrates that the embedded emissions of its product are lower than the EU default value, this presumption is carried into the year after the emissions actually took place. However, MRV.Ap.3 seems to be a feasible compromise: If the period for the "reconciliation" is chosen in a suitable way, there would be some overlap between the period of actual emissions monitoring and imports (see Figure 5-3). Hence a timetable, such as the one proposed in the figure, might be both acceptable for stakeholders as well as feasible in practice (although delays might still happen in particular at the stage of accepting the non-EU operator's emission report). As suggested in Section 5.2.6 the reporting period of the non-EU producer does not have to coincide with a calendar year, so the amount of overlap of emissions and import periods may still differ to various extents.

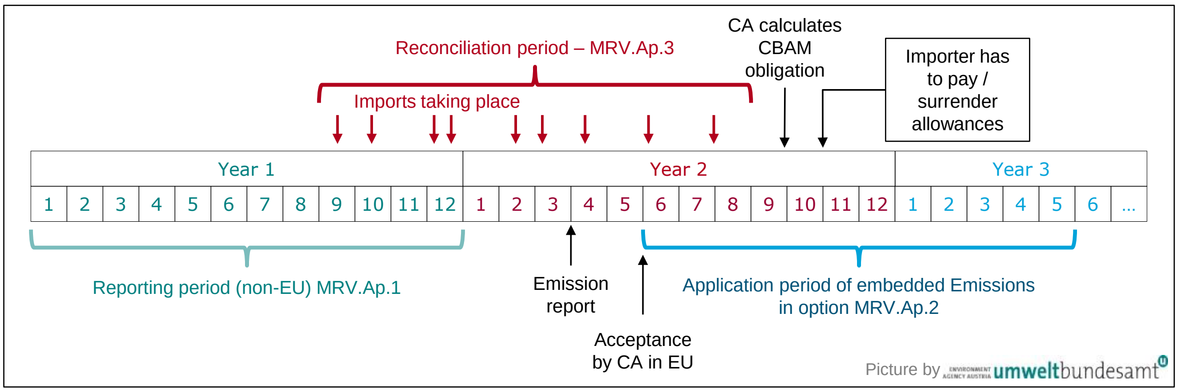

Figure 5-3: Possible timeline for a CBAM compliance cycle.

To define a possible timetable for the CBAM compliance cycle, we have taken into account that in Section 5.4.1 it is proposed that the competent authority might be the same as for the EU ETS in the Member States, since the relevant competence on GHG emissions MRV is already available there (alternatively, it could be an EU authority). If this approach were followed, it would be important to set the CBAM deadlines very differently from the deadlines of the EU ETS compliance cycle, in order not to create unnecessary workload peaks. This would make a reconciliation deadline between September and December desirable. Consequently, the CBAM compliance cycle could be defined as in Table 5-3.

Table 5-3: Proposed timeline for a CBAM compliance cycle

When?	Who?	What?
1 Sept. Y-1 to 31 Aug. Y	Importer	Declare import data of CBAM reconciliation year Y.
By 30 Sept. Y	CA	Carry out reconciliation: Calculate CBAM obligation and request importer to pay or surrender allowances, as applicable.
By 31. Oct. Y	Importer	Pay / surrender allowances
Any day	Operator in non-EU country	Submit a verified emission report to CBAM authority regarding embedded emissions. This "any day" will be approximately 3 months after the one-year reporting period.
Any day + approx. 2 months = day X	CA	Accept the emission report after carrying out checks.
1 Sept. Y-1 to 31 Aug. Y, where day X falls into this	Importer and CA	Apply the embedded emissions data to imports that happen in this period.

When?	Who?	What?
period		

5.3 Calculation of the CBAM obligation

The calculation of the obligation for an imported good under the CBAM will require some approximations or estimations in order to simplify it to a level that can be handled in everyday administration. However, in order to understand the principles, we start by discussing how the "perfect" level of GHG emissions costs embedded in a material or product would be calculated. First, the exact carbon costs embedded in a material or product fully produced in the EU must take the following into account.

- Total emissions costs comprise the sum of all the direct emissions covered by the EU ETS during the production of each material needed to produce the material or product under consideration, multiplied by the relative amount of the material needed to produce the final material or product under consideration.
- Total direct emissions costs are reduced by the levels of free allocation in each of the production steps. This information can be omitted (set to zero) if there is full auctioning (i.e. for Options 1, 3, 5). The same is true under Option 4, where payments under the excise are not affected by free allocation.
- Total indirect emissions costs are composed of all the electricity required in all the included production steps, multiplied by the cost increase of electricity attributable to the EU ETS.
- Total indirect emission costs are reduced by any compensation for indirect cost increases granted by Member States to these production processes. Depending on CBAM design (if support for indirect emissions is phased out like free auctioning), this information can be omitted.

Taking all the above into account, the "perfect" level of GHG costs for **a material produced in one single step under the EU ETS** (such as ammonia) would be:

Equation (1): $CC_{EU} = P_{EU} \cdot (EM - FA) + IC - ICC$

where CC_{EU} are the carbon costs for one unit (e.g. a tonne) of the material, P_{EU} is the allowance price (determined using one of the methods described in Section 5.1), *EM* the emissions attributed to that production using actual MRV rules[101] under the EU ETS, *FA* the level of free allocation granted per unit of production[102], *IC* the indirect costs from electricity consumption per unit, and *ICC* the indirect cost compensation level per unit, if applicable.

If this formula is **applied to a value chain** that requires several basic materials to be mixed or used in chemical reactions, including also where some parts of materials are consumed or lost, the following equation applies:

Equation (2): $CC_{EU} = \sum_{i=1}^{n} MC_i \cdot [P_{EU} \cdot (EM_i - FA_i) + IC_i - ICC_i]$

[101] That is, by applying the M&R Regulation, A&V Regulation, FAR Regulation and ALC Regulation.

[102] Calculated from product benchmark or fall-back approach as appropriate, taking into account carbon leakage factor, cross sectoral correction factor or linear reduction factor as appropriate.

In this case the index *i* indicates the materials 1 to *n*, and MC_i the amount of material *i* consumed for one unit of the material or product under consideration.

By replacing the actually monitored emissions EM_i by a reference value REM_i determined for the whole EU[103], it is possible to define a standard value for materials or products to be covered by a CBAM on imports.

To take into account the possibility that a CBAM on imports might give rise to a rebate for emission costs already borne in the country of origin, a similar formula could be used to deduct those emission cost from third countries. However, it must be noted that theoretically different components of the material or product can be produced in different countries, so that not all the materials bear emission costs. To make this clear, a "*CO*" index (country of origin) has been added. Furthermore, it is a theoretical possibility that one material *i* is produced in more than one country and quantities are mixed later in the production process. Therefore, the second part of the equation uses the index *j* in order to indicate that this may be different than *i*. The equation for the CBAM obligation (if expressed in euro, not allowances) then reads as follows:

Equation (3):

$$CBAM = \sum_{i=1}^{n} MC_i \cdot [P_{EU} \cdot (REM_i - FA_i) + IC_i - ICC_i] - \sum_{j=1}^{m} MC_j \cdot [P_{CO} \cdot (EM_{j,CO} - FA_{j,CO}) + IC_{j,CO} - ICC_{j,CO}]$$

Note that, in principle, this CBAM obligation could become negative if the carbon costs borne outside the EU were higher than the EU carbon costs. For this situation, the CBAM legislation should ensure that the CBAM obligation would be zero as a minimum, i.e. there cannot be payments from the EU to the importer to compensate for the carbon costs in third countries. This would be counterproductive given the fact that the CBAM should help to avoid carbon leakage, not increase its risk.

It seems clear that it will be possible to fully calculate Equation (3) only in very rare cases, where the full cooperation with the country/countries of origin is obtained. Hence, to make it useable in practice, the following simplification steps are possible and should be considered for the actual implementation of a CBAM.

1. As at the current stage all emission trading systems grant free allocation, their actual costs on emissions embedded in materials and products are near to zero. Therefore Equation (3) can be discarded, and only Equation (2) used.

2. The terms $EEM_i = (REM_i - FA_i)$ can be developed based on EU ETS data and listed as single reference values for "embedded emissions" (EEM) for each material in the relevant CBAM reference documents. Note that in case of full auctioning (*FA=0*), *EEM_i would be identical to REM_i*, i.e. the determination of EEM_i will be considerably simpler.

3. Similarly, reference default values for the material content MC_i should be developed by an expert group (by building on BAT reference documents and other industry data, if possible).

4. For most materials/products, indirect costs play a minor role. Therefore, in most cases the variables IC_i and ICC_i can be omitted. For those cases where they are relevant, single

[103] In the literature, the term "benchmark" is often used, but to avoid confusion with the EU ETS benchmarks this study uses "reference value" as the more general term.

reference values $EIE_i = IC_i - ICC_i$ (Embedded Indirect Emissions) should be developed and listed in in the relevant CBAM reference documents. If full auctioning is assumed, we assume also that there would be no indirect cost compensation (*ICC=0*).

5. By combining steps 2 to 4, single reference values for the "embedded emissions" of each material or product can be developed. Those *EmEm* values would also be constants which should be listed in reference documents:

Equation (4): $EmEm = \sum_{i=1}^{n} MC_i \cdot (EEM_i + EIE_i / P_{EU})$

Those **Embedded Emissions** (*EmEm*) values would in principle only require multiplication with the amount of the import (in tonnes) to result in the amount of allowances to be surrendered, or – in case of an import charge – would have to be multiplied by the reference carbon price and the amount of material or product to give the amount to be paid. Note that in Section 5.2.3 several options are discussed for what parameters should be included in the embedded emissions. The formulae above – in particular Equation (3) – give the most complex case (Option EE.1). Formulae for the other options can be easily derived based on what has been said above regarding simplifications.

5.4 Practical implementation and forms of payment

While the excise under main Option 4 is by definition a tax, for the main options 1 to 3, the modality of "payment" of the CBAM obligation can be one of the following:

- Option Pay.1: the surrender of "notional" allowances (i.e. allowances which cannot be used for compliance by operators of installations or aircraft operators);
- Option Pay.2: the surrender of EU ETS allowances; or
- Option Pay.3: a tax (i.e. a payment expressible in euro).

In Sections 5.4.2 to 5.4.4 we will discuss how the CBAM can be implemented in practice for these "Payment" options. Before that, however, we will explain in Section 5.4.1 elements that can be described jointly, which in particular relate, but are not limited, to administrative aspects.

5.4.1 Practical implementation of Options 1-3

As a preview of what is discussed later in this Section, Figure 5-4 shows how in principle a CBAM on imports (main Options 1 to 3) could be set up. The roles of the competent authority, the need for a central database called the "CBAM facility" and other elements are described in this section.

In Figure 5-4, Product A is produced in a single installation without any upstream emissions, and the importer has decided to make use of actual emissions data (Option DV.2, see Section 5.2.6) provided by the operator of the installation outside the EU which produces Product A. The CBAM design chosen for the picture uses the payment modality "tax" (Option Pay.3, see Section 5.4.1), hence no registry account for allowances is shown. Furthermore, the example assumes that an annual "reconciliation" is made based on all imports of that year (Options Cycle.2 or Cycle.3, as described in Section 5.4.1).

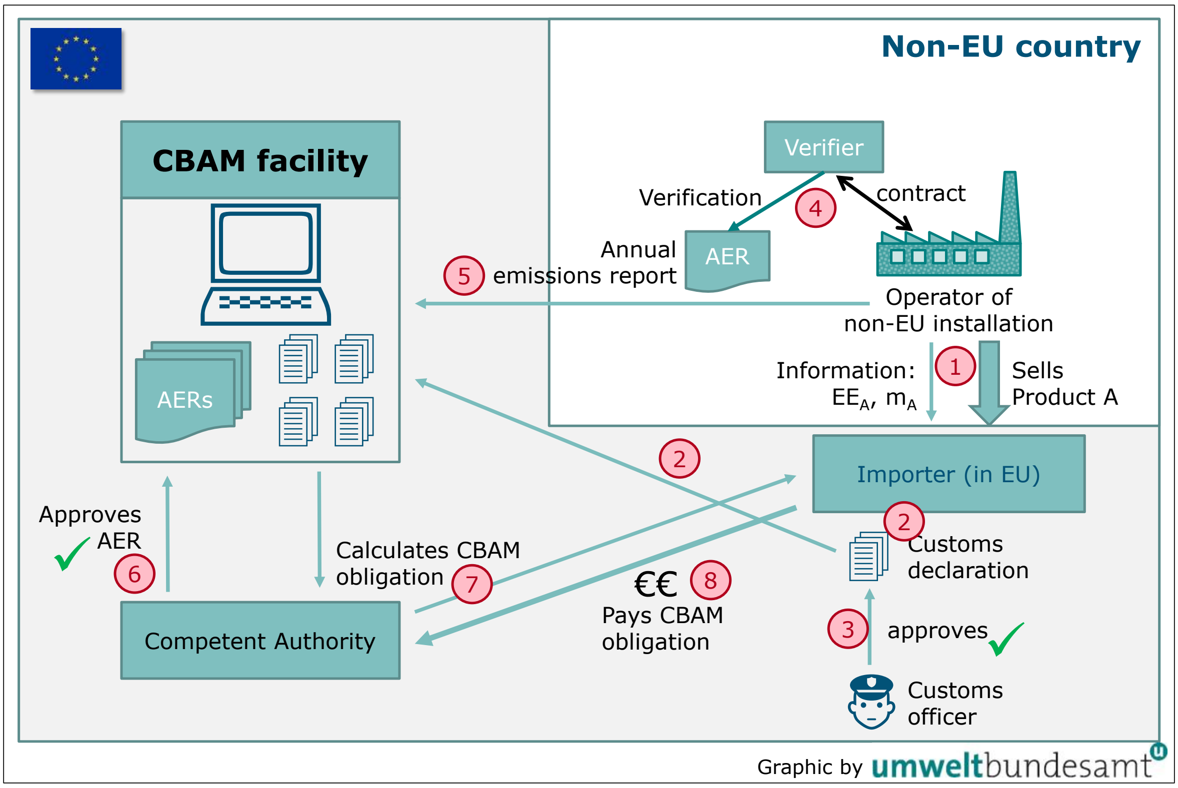

Figure 5-4: ***Overview of the processes and institutions forming the basis for the description of the CBAM design described in this chapter for Options 1-3. The red numbers give the sequence of the steps.***

As will be discussed below, the three payment modalities have consequences in terms of implementation. Consequently, we need to distinguish and discuss the following options. The choice of the payment modality impacts which of the following options is to be preferred.

- Option Cycle.1: an immediate payment at the time of the import.
- Option Cycle.2: the payment is delayed to the time of a "reconciliation" of data, and a more EU ETS-like "compliance cycle" of (annual) monitoring, reporting, verification and "payment" is implemented.
- Option Cycle.3: This is a hybrid approach with elements of Cycle.1 and Cycle.3. It is only proposed in context of a tax as payment methodology (Option Pay.3). It is consequently described only in Section 5.4.4.

A big impact in all cases comes from the design choice of whether the CBAM should always be based on default values for the embedded emissions of materials or products imported (Option DV.1, see Section 5.2.6), or whether importers should be allowed to demonstrate the actual values for embedded emissions based on the monitoring of emissions of the installation(s) where the imported good was produced (Option DV.2). The design choice also leads to different choices for the competent authorities, and on who should be the (legal) person obliged to "pay" the CBAM obligation. However, the latter impacts are less pronounced and will not be discussed in form of distinct options here.

For the discussion of common elements in all the said CBAM implementation approaches, it is useful first to consider **how customs operate in general**. Nowadays customs operations are mostly based on information provided by one of the trade partners via electronic databases in advance of the physical import taking place. In a normal case of a good's import into the EU, one of the following actors has to file the customs declaration and pay the respective taxes and duties, if applicable:

- the producer or a trader in the third country;
- the importer situated in the EU (a trading company or user of the good);
- a freight company;
- an intermediary or service company on behalf of one of the above.

Various electronic tools and databases are available to support this process. In particular, the TARIC[104] database gives precise information on all relevant tariffs and other legal requirements applicable to each good (by CN code[105]), by country of origin and destination. Helpdesks exist in many countries for importers and exporters to determine the CN code and related taxes and duties correctly. Therefore, in the overwhelming majority of cases a customs officer is able to clear the transaction from his office's desk within few minutes, without actually inspecting the good. Physical inspections usually take place only for a small sample of cases, using a risk-based approach. The total number of cases is vast (according to the Commission's website[106], there are about 343 million customs declarations to be handled per year, i.e. almost one million per day). Therefore, customs concentrate primarily on the formal requirements of a completely filled declaration. There are cases where certain certificates or supporting documents are required (e.g. conformity with specific EU legislation). In case of the CBAM, a verification report regarding the actual emissions embedded in an imported material would be such a supporting document. In this report we assume that the customs officer would only check the *existence* of such document (should the chosen design option require this[107]). However, for actual checking the *content* of such a verification report, we assume that either a third-party verifier (as in the EU ETS), a dedicated inspectorate or a competent authority more familiar with emission reporting would be in charge.

Who is obliged by the CBAM? As mentioned above, a variety of actors from inside and outside the EU can be responsible for the customs declaration. However, if the CBAM duty is not to be paid immediately upon import (as proposed for the allowance surrender options), a credible enforcement mechanism must be established. Therefore, the preferred option is to require an entity with its seat in the EU to be liable for compliance with the CBAM. As REACH shows, such a requirement is useful as well as feasible. On the other hand, the EU ETS for aviation shows that it is also possible to oblige third-country operators. However, in that case, an effective deterrent penalty mechanism was found to be required (see below). For this reason, the first choice is to have a requirement that for every import which falls within the scope of the CBAM, the importer nominates in the customs declaration a "CBAM importer"[108] (similar to the installation operator in the EU ETS) with a business address in the EU, if the customs declaration is not filed by the "CBAM importer". Alternatively (and potentially simpler), the CBAM would require that the customs declaration for goods falling within the CBAM are only allowed to be filed by such a CBAM importer.

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[104] https://ec.europa.eu/taxation_customs/business/calculation-customs-duties/what-is-common-customs-tariff/taric_en.

[105] In the scope chapter (chapter 4) the HS codes were used for their higher aggregation level. Internationally used HS codes have only 6 digits, which form the first 6 digits of the 8-digit CN codes used by EU customs. Hence, full compatibility is given. For practical reasons, in this chapter the reference to CN codes seems more appropriate.

[106] https://ec.europa.eu/taxation_customs/sites/taxation/files/facts_figures_en.pdf.

[107] It is irrelevant if only default values for embedded emissions are allowed.

[108] It is possible to consider whether service providers should be allowed to do the paperwork for the CBAM for several importers. They would then have to act as CBAM importers on behalf of the importers, thereby reducing the number of entities to be administered.

This would mean that importers would first have to register as "CBAM importers", and only importers located in the EU would be allowed to do so. Following registration the "CBAM importer" would then be attributed to a specific competent authority which would be in charge of compliance checking and enforcement for this operator from registration onwards. This would be similar to the way in which aircraft operators are attributed to administering Member States in the EU ETS. Note that this "compliance checking" would relate to any MRV and surrender obligation, while the actual (formal) clearing of the customs process would remain with the customs office (but as mentioned before, this would rather be a formal check, not a check of actual emission reports).

Note that as an alternative the system could also be set up in a way that theoretically all the above-mentioned groups (producers, traders, consumers, freight operators), independent of being established in the EU, could be obliged just as in normal customs practice. However, for enforceability reasons, this would only be feasible for a single design option, i.e. for a tax to be paid immediately at import, using only default values for embedded emissions without allowing any own declaration of emissions.

Who is the competent authority (CA)? In line with the above explanations, it seems logical to split responsibilities between customs offices in the Member State that would be in charge under normal circumstances, too (i.e. without CBAM), and a CA that is specialised in ETS-like activities, as follows.

- The **customs office** would check the customs declaration for the formal points, in particular whether the CBAM applies. It confirms whether all relevant data have been entered into a "CBAM tracking database" by the responsible "CBAM importer" together with the customs declaration.

- **For other administration tasks** necessary for implementing the CBAM, i.e. registration and management of the CBAM importers, of the related registry accounts, for checking the compliance of the "import emission reports" and enforcement of the allowance surrender, another CA should be used. The existing EU ETS authorities in the Member States would be well placed due to their competence and familiarity with many of the required tasks, but it might also be possible to set up dedicated CAs in the Member States. To facilitate one-stop-shops, every importer should be assigned to one MS only (based on the place of its establishment). However, as the CBAM is intended to deliver revenues directly into the EU budget, it might be more useful to set up a dedicated EU agency for performing those tasks.

- **A (central) "CBAM authority"** would have to be in charge of coordinating and supervising the functioning of the CBAM across the EU, as the Commission is currently steering and supervising the EU ETS. The responsibilities of this CBAM authority might include the collection of revenues and refunds in case data reconciliation shows that a CBAM importer "paid" CBAM obligations in excess of the relevant embedded emissions. Revenue management would go hand in hand with the management of CBAM-related allowances in the EU ETS Registry system (Options Pay.1 and Pay.2). Furthermore the authority would be in charge of central processes such as determining and regularly updating the scope of the CBAM (products covered and their relevant definitions), determination of default embedded emissions values, determining "rebates" for imports from countries/jurisdictions with effective carbon pricing in place, and organising an information exchange among involved competent authorities, in particular by managing the development and operation of the CBAM facility (see discussion of "infrastructure" below).

Should the CBAM apply immediately at the time of the import (Option Cycle.1), or should there be a longer "compliance cycle" as in the EU ETS (Cycle.2)? To answer this question, it may be useful to consider that theoretically duties can apply equally to a bulk load ship (approximately

100 000 t of goods), to smaller ships or whole trains, to single containers and truck loads, but even to small packages sent by normal mail. For a CBAM based on a tax (i.e. where the obligation is met by a simple payment), the size of the import at hand seems of no issue, the payment can be made immediately upon import, and the customs office can immediately clear the import.

However, in a CBAM system using the surrender of (notional or EU ETS) allowances, a certain minimum size of import would be required for establishing a similar treatment to products produced in an installation covered by the EU ETS, because the smallest unit for emissions in the EU ETS is a (metric) tonne of CO_2 equivalent. Let us assume that the default embedded emissions[109] in the CBAM for a tonne of material is 2.13 t of CO_2. If a manufacturer in the EU imports a whole train load of that material (about 1 000 t), the CBAM obligation would be calculated as 2 130 allowances to be surrendered. However, if a manufacturer had to import the same quantity by truck (approximately 25 t per load), this would be 40 loads. If mathematically rounded, this would be 53 CBAM allowances per truck, or only 2 120 allowances for the same 1 000 t of material. For this reason, we assume that for a CBAM using notional allowances an annual "compliance cycle" as in the EU ETS (Option Cycle.2) would be more appropriate, while for the taxation approach both immediate or aggregated payments could be considered.

Requirement to reconcile data (e.g. annually). Independently of whether a tax or a surrender of allowances is used for the CBAM on imports, the need may arise to correct the amounts of payment made if it is discovered at a later stage that an incorrect material was declared. Secondly, if an import's actual embedded emissions are allowed instead of default values, a correction of the number of allowances to be surrendered will often occur, when the CA detects errors in the emission reports or verification reports submitted for the imported goods. In the system designs where not only default values may be used, it is therefore proposed that such reconciliations should be mandatory for the CA to perform. However, even with a tax design with only default values, a mechanism for later correction of payments may be needed.

Should there be a de minimis threshold? In principle there is no threshold for the single transaction in customs. As mentioned above, even small packages can be obliged to have a valid customs declaration and some duty paid before their import is allowed. Consequently, for the simplest design (tax with only default values), there seems to be no reason why such a minimum threshold would be required. However, for the inclusion in the CBAM, mostly basic materials and intermediate products are considered, which are rarely traded or handled in small quantities anyway. For practical reasons it may be useful to limit the application of the CBAM to imports above a certain size, e.g. at least a tonne of material (i.e. roughly in the order of magnitude of one palette, one big bag, or a cubic metre of liquid), while using a threshold of a standard container or truck load may too big and might encourage gambling (combining different goods in one container). However, depending on other design choices (reconciliation process, level of automation, etc.), such limitation does not seem to be a mandatory design feature. It could be introduced for the test phase, and when found irrelevant, be dropped at a later stage, or vice versa.

Also, with respect to the obliged entity (the importer), it may be useful to consider a minimum threshold for the obligation. Again, it would not make sense for the simple tax/default value case. However, reducing the number of obliged entities would be useful in system designs where the obliged entity has to surrender allowances, and where a competent authority has to check annual emission data. Such design would limit administrative burden at a reasonable level: The competent authority would need to supervise fewer entities that are obliged to submit "import emissions reports", and check fewer such reports. Furthermore, fewer importers would need an

[109] Note that this is a purely fictional figure.

account in the EU ETS Registry and would therefore have to undergo the relevant registration formalities (including "know your customer" checks).

For example, it would be possible to exclude importers who import less than 1 000 tonnes per year of materials covered by the CBAM. The basis could be the average of the three years preceding the introduction of the CBAM. All products covered should be aggregated per importer. For example, if a company trades metals, the annual imports of 600 t steel, 300 t aluminium and 101 t copper would make it "CBAM obliged". For "new entrants" (companies who do not know yet if they will exceed the threshold) the rule could be that as soon as the 1 000 t/yr are exceeded, the importer becomes obliged by the CBAM from the following calendar year onwards. Eventually, rules could be set up for allowing groups of subsidiary companies to determine one legal person as their joint "CBAM importer" (i.e. the importer responsible for the whole group of companies).

The benefits of reducing the number of obliged entities may, however, be outweighed by the additional effort to determine who is obliged or not. The alternative approach would be that an entity could become obliged from its first import covered by the CBAM onwards. This would potentially mean that a registration with the competent authority would be required upon the first import, or even before the actual start of the CBAM. As both approaches seem feasible, no recommendation on design is made. Instead, the design choice should be reviewed after experience has been gathered over the initial years of CBAM implementation.

Penalty mechanisms. Non-compliance with the CBAM is likely to happen in the following situations, leading to different needs for penalty mechanisms.

- If the immediate obligation upon import is not met.
    - In case the CBAM obligation has to be fulfilled immediately at the time of import, no specific penalties would be required for non-compliance regarding "payment" of the CBAM obligation. The import would not be cleared until payment is made.
    - In case the obligation is to be fulfilled at a later point in time (using e.g. an annual compliance cycle approach), a penalty for meeting the obligation late, incomplete or not at all may be relevant.
- When the CA detects that incorrect data was declared for the embedded emissions (e.g. declaration of incorrect type of material in case of default values): In such cases it might be relevant to adjust the number of allowances to be surrendered (or to recalculate the amount of import tax to be paid). An administrative penalty for the non-compliance would be due. In line with the EU ETS, the introduction of a penalty of EUR 100 per non-surrendered allowance could be considered. This would be imposed on top of the surrender obligation, i.e. not waiving it.
- A special case would occur in a CBAM design that allows the importer to demonstrate their own value of specific embedded emissions: as in the previous point, the amount of CBAM obligation would require recalculation. However, there would be more potential actors involved than the CBAM importer, and consequently several types of incorrect data may occur.
    - Mistakes (unintentional or intentional) can occur during monitoring and reporting at the installation where the material or product is manufactured (i.e. outside the EU). In the EU ETS, such mistakes are minimised by detailed legislation which applies a well-balanced distribution of responsibilities. In particular, the selection of monitoring approaches is not at the discretion of the operator, but is enshrined in a detailed monitoring plan approved by the competent authority, and data is verified by an independent verifier who has to obey defined rules in order not to lose its

accreditation.

As the relevant monitoring for the purpose of a CBAM would take place outside the EU, the respective operator cannot be held responsible. However, the importer might face a financial penalty and might try to pass on the respective costs to the operator of the producing installation. Eventually the importer could decide not to buy from that producer anymore. It is uncertain if this would be "effective, proportionate and dissuasive"[110].

At the high end of the penalty range, by way of example the EU ETS Directive contains a clause which is relevant in particular for non-EU operators. When all other means fail to make an aircraft operator comply with the EU ETS, the ultimate penalty is an operating ban for the aircraft operator. This may even involve grounding aircraft at an EU airport[111]. In case of a CBAM, this could be translated into a ban of imports from that producer. At present this type of penalty does not seem advisable. It might be disproportionate and possibly easy to circumvent. However, ensuring compliance will be an important task to make the CBAM credible and robust, and experience should also be gathered regarding enforcement measures and relevant best practices from Member States.

- Mistakes in verification of emissions. If verifiers are under strict supervision by EU authorities, they can greatly contribute to the confidence about the reliability of data reported by manufacturers even if they are outside the EU. In order to design strict supervision, the starting point should be that verifiers would have to be accredited in the EU and to apply the AVR[112] and – where the AVR does not apply – international standards. Consequently, the mechanism for severe mistakes by verifiers would be administrative measures by the national accreditation body where the verifier is accredited. Ultimately the verifier's accreditation could be withdrawn.

- Incorrect declaration of the origin of the material for which CBAM obligations arise, with the aim of declaring lower embedded emissions or to circumvent the CBAM in case products from some countries would be exempted from the CBAM, e.g. because they have their own ETS: This may range from unintentional mistakes (which can be simply corrected at CA level) to significant cases of fraud. Consequently, the full range of legal instruments and prosecution bodies in the Member States should be available to tackle such cases, and to make fraud unattractive. However, as the EU ETS has shown, such severe cases often do not have to be specifically mentioned in a legal instrument, since general legislation exists in the Member States for all kinds of fraudulent and criminal activities.

Infrastructure required: In order to avoid paperwork and to process all data electronically right from the start of the CBAM, the establishment of a specific **CBAM facility** (a secure electronic registry system) set up at EU level would be highly recommended. It would have to link to the relevant customs database(s), manage the data (import data and "import emission reports", if applicable) of the "CBAM importers", allow access for the relevant CAs and verifiers, and store all emission data of installations in third countries which report emissions for the purposes of the CBAM. For the CBAM designs involving the surrender of allowances, a technical link to the EU ETS Registry system could also be useful (depending on the detailed implementation approach).

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[110] Article 16(1) of the EU ETS Directive.

[111] Article 16(5) of the EU ETS Directive: "*In the event that an aircraft operator fails to comply with the requirements of this Directive and where other enforcement measures have failed to ensure compliance, its administering Member State may request the Commission to decide on the imposition of an operating ban on the aircraft operator concerned*".

[112] Accreditation and Verification Regulation for the EU ETS, Commission Implementing Regulation (EU) 2018/2067.

In case the CAs are situated in the Member States and not at EU level, an organised information exchange between CAs has to be established. In particular the central repository for verification reports of different installations outside the EU would be required (as part of the CBAM facility). Only in this way can different importers use the same information for imports from the same installation. Furthermore, CAs could share the work of checking emissions reports and verification reports of non-EU producers, and all MS need to be informed if incorrect declarations or even cases of fraud are detected in this process. Having the task bundled in an EU agency could facilitate the administration (comparable to Eurocontrol's role in providing information to the Commission and Member States, and automatic emission reports from its "ETS support facility" for small aircraft operators).

5.4.2 Surrender of notional allowances (Option Pay.1)

In this section, an outline is given of how a CBAM could work in practice, if the surrender of notional allowances is required for emissions that took place during the production of imported goods. This section therefore applies to Options 1a and 1b, 2 and 3 with the "payment" modality that notional allowances are to be surrendered. Following on from Section 5.4.1, the most appropriate design choice would apply Option Cycle.2 (annual compliance cycles), as described below under "How would it work?". For illustrative purposes, we then provide a description of the process using Option Cycle.1, i.e. immediate "payment" of the CBAM obligation.

How would it work?

For existing customs processing and statistical data collection, every import has to be accompanied by the so-called "Single Administrative Document" (SAD[113]), which contains all essential information for administering customs transactions, such as origin and destination of the good, its nature (by using CN codes), its mass and value, and the calculated taxes and duties to be paid. If the CBAM were implemented by means of a tax, the resulting tax amount would have to be entered into the SAD. However, in case of allowance surrender this would not be the right place to do so. Instead, an entry would be required which mentions the fact that the CBAM is to be applied. This would then trigger a requirement to add further information into the "CBAM facility". All further information would have to be attached in separate documents to the SAD[114], or only be held in the CBAM facility, provided that the customs office can access it and confirm that the required data has been declared.

- The amount of allowances to be surrendered should be provided by the importer in the CBAM facility. If the importer intends to provide its own emission figures for the CBAM, the relevant information is also to be provided. Depending on the MRV requirements defined, the relevant information here would be either:
    - the confirmation that the imported good falls under the CBAM (this is sufficient if the default value for embedded emissions can be determined based on the CN code alone); or
    - the specific embedded emissions determined in line with the EU CBAM requirements on MRV – in this case, a kind of verification report would have to be attached.

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[113] https://ec.europa.eu/taxation_customs/business/customs-procedures/general-overview/single-administrative-document-sad_en.

[114] This can be done in the SAD, as it can identify such additional information in section 44 ("Additional information/documents produced/certificates and authorizations").

- Furthermore, the following information should be automatically transferred from the customs database to the CBAM facility, in order to avoid additional administrative burden or inconsistent data.

    - The identification of the actual importer (the recipient of the goods) and the "CBAM importer" responsible (if different).

    - The CN code [and name] of the material or product imported.

    - The quantity of the imported material or product.

    - The associated specific embedded emissions factor – if the default value is used, it should be automatically provided, based on the CN code.

If non-default values are claimed for embedded emissions, identification[115] must be provided of the installation of origin and the country/jurisdiction where it is situated, in order to confirm if carbon pricing applies there.

    - If applicable: a scan of the emissions report of the producing installation and the related verification report for the embedded emissions. It should be feasible that the latter is provided only once by the installation, and thereafter it can be referenced by all importers buying from that installation.

- When clearing the customs declaration, the customs officer would check, on the basis of the CN code of imported goods, whether they fall under the CBAM, and whether the relevant data has been reported in the CBAM facility. In CBAM designs where immediate payment is due, the customs officer will also check whether the relevant amount has been paid, while for systems with later surrender of allowances, only the fact of the data entry and consistency with the customs declaration will be checked.

At regular intervals (e.g. annually[116] as for the EU ETS), the "administering CA[117]" would perform a calculation (or "reconciliation") of the CBAM obligation by adding up all the emissions reported by that CBAM importer for the previous period (e.g. the calendar year) and for all imported products covered by the CBAM, using the CBAM reporting facility. In CBAM designs where only default values for the embedded emissions are allowed, this is a simple addition of quantities multiplied by those default values. However, in other CBAM designs, if the importer claimed to have lower embedded emissions, those claimed values would have to be used. Therefore, as a part of this calculation, the CA (or an accredited third-party verifier, depending on the design choice) would also check [a sample of] the emissions and verification reports attached to the customs declarations.

- The CA informs the importer of the calculated amount of allowances to be surrendered by the deadline which would be fixed by the CBAM legislation (e.g. one month after transmission of the information on the amount of the obligation). The importer would then have the possibility to provide updated/corrected data, if relevant, before surrendering the allowances required.

[115] All installations providing emissions data and verification reports would have to be registered in the CBAM facility.

[116] This longer period instead of handling each import separately seems useful to avoid rounding issues (only full tonnes of CO_2 equivalents can be surrendered). It would also be a means of reducing the administrative burden and potential errors.

[117] This approach to let the CA do the calculation is somewhat like CORSIA for emissions from international aviation. Alternatively, the obligation to produce the calculation could be given to the importer. However, this seems more complicated and more onerous for the CA to enforce.

- The importer surrenders the necessary amount of allowances, which it has purchased either throughout the reporting year or after having learned about the amount to be surrendered. How this can be organised is discussed below.

An alternative mechanism using Option Cycle.1 could be construed as a hybrid of the tax and allowance surrender process:

- To simplify the process for the importer, the CBAM obligations would be paid immediately on import, i.e. the day's actual carbon price[118] would be multiplied by the embedded emissions of the imported good, and the resulting amount of euro would be collected by the customs office, who transfers it to the "CBAM authority" which would be in charge of administering the money flows for the Commission.

- The payment would trigger an automatic generation and subsequent cancellation of notional allowances in the registry, and the importer would not need its own registry account. In case of fractions of whole allowances, the CBAM facility would ensure that smaller units than full tonnes CO_2 could be handled appropriately.

However, there may still be a need for a reconciliation mechanism. Firstly, there must be the possibility to correct the amounts of earlier payments made in case it is discovered that an incorrect material was declared. Secondly, in case an import's actual embedded emissions are allowed instead of default values, a correction of the number of allowances to be surrendered could often happen, when the CA detects errors in the emission reports or verification reports submitted for the imported goods. Hence, when applying the reconciliation mechanism, it would be more appropriate to classify this design under Option Cycle.3.

How are notional allowances generated, purchased, surrendered, and can they be traded?

The implementation for all options below would be similar insofar as the Registry system would have to be updated by the introduction of a new type of allowance, which could be named, for example, **EUIA, for "European Import Allowance"**. Without prejudice to any such Registry development in the future, this abbreviation will be used in the present section for ease of reference.

In this section, we need to discuss two options, with a third one for the specific case of Option Cycle.1 (immediate surrender on import) as described above.

- **Option NoA.1 - Non-tradable EUIAs.** These would be created "on demand" (but in principle without limitation) and only CBAM importers would be able to buy and hold them in order to use them for meeting their surrender obligation under the CBAM. The price for the allowance would follow the price of the EUAs[119].

- **Option NoA.2 - Tradable EUIAs**. in this case the number of allowances would have a kind of cap, the allowances would be freely tradable and their price would evolve from a balance of supply and demand. It would be possible to allow other market participants to buy, hold and sell the notional allowances, thus increasing liquidity in the market.

[118] Note that – unlike for other surrender-related CBAM designs – here the different carbon price options (see Section 5.1) could be applied.

[119] EUAs: EU ETS allowances for installations; Theoretically, EUAAs (allowances for aviation) have their separate market. However, from 2021 onwards both types of allowances can be used for compliance by both EU ETS operator groups, hence their prices should converge.

- **Option NoA.3 - Automatic issue/surrender mechanism**. The CBAM importer would not hold the EUIAs on its Registry account, but they would be held in only one central account managed by the Commission (or the above-mentioned central "CBAM authority") and linked automatically to import transactions tracked by the CBAM facility. This would be the method of choice for the Option Cycle.1 (or Cycle.3) in connection with notional allowances (option Pay.1).

For all options, the Registry system would have to be updated with a new type of allowance (the EUIAs) and new processes for creating, transferring, holding, surrendering and cancelling allowances. For Options NoA.1 and NoA.2, a new type of account (importer holding account) might be introduced, or at least a means to hold the new type of allowances in existing account types. In line with the compliance process of operators or aircraft operators, a kind of compliance flag would have to be introduced for CBAM importers' accounts.

Functioning of Option NoA.1: In principle, there would be no need to consider a limit for the creation of EUIAs. Whenever a CBAM importer wants to buy an EUIA, it is created in the Registry (under supervision of the CBAM authority) and transferred to the CBAM importer's account. The price to be paid and collected by the CBAM authority (possibly via the customs authority) would be set by one of the options discussed in Section 5.1. The relevant price would be published by the CBAM authority at relevant intervals (e.g. annually, monthly, every workday), and would be directly available in the CBAM facility, i.e. also available to the customs office[120].

The surrender of allowances would take place at the latest by the deadline set in the "compliance cycle", which may be, for example, one month after the CA has fixed the amount to be surrendered after the reconciliation, as mentioned above in the description of Option Cycle.2.

As the CBAM importer might want to buy EUIAs in advance for its imports, without yet knowing how many allowances will be needed (including uncertainty about whether the CA will accept the relevant emission data, if not only default values are used), some banking of EUIAs should be allowed, for instance, allowing their use at least for the subsequent year. However, there would be no requirement to allow them to remain valid indefinitely. Giving the EUIA an expiry date would incentivise the importers to buy them not too much in excess, and thereby would mean that EUIA purchases better reflect the actual EUA price. Furthermore, a process may be included in the CBAM design for allowing importers to selling excess EUIAs back to the CBAM authority.

Functioning of Option NoA.2: The EUIAs would be created in the Registry system and auctioned just like normal allowances, following a defined cap and auctioning calendar. However, this might lead to speculation and price spikes, as it would be quite difficult to set the cap at the right level of demand by importers. As the supply/demand balance would be different than for EUAs, it is likely that the importers would face a different CO_2 price than an operator in the EU ETS. Speculation aside, there would be an oversupply (i.e. too low a price) if the cap were based on too high import expectations, and significant scarcity (high price) in case of unexpectedly high imports. This would be an undesired effect, even if sophisticated mechanisms were introduced to balance the real demand, for instance, based on flexibility to adjust the cap in following years, as it would probably lack predictability, thereby not being able to prevent prices diverging from the EUA price.

Alternatively, EUIAs could be created only when a CBAM importer buys them directly from the CBAM authority as in the previous option. The buyer would have to demonstrate the demand to buy them (i.e. proof of making imports). The permission to trade would only serve the purpose of ensuring that the CBAM authority does not have to buy back EUIAs that are not used by the

[120] In case Cycle.1 is linked to Pay.1, this would define automatically the amount of payment due at import clearing.

importer. A sort of capping mechanism would be required. The CBAM authority would have to track the number of EUIAs created in comparison to the expected demand, based on imports already declared in the CBAM facility. If a certain level of imbalance were reached, the authority would not create additional EUIAs but refer any potential buyer to the secondary market.

It seems clear that Option NoA.2 is complex to administer and could lead to undesirable outcomes. Therefore, only Option NoA.1 is recommended for a Cycle.2-like design. Option NoA.3 is the logical choice only for the Cycle.1 (and Cycle.3) designs.

How would an export rebate be implemented using notional allowances?

If main Option 3 (CBAM not only on imports, but including support for exports) were to be implemented by using the "payment method" notional allowances, the following would apply:

For determining the amount of materials actually exported, in principle the same process of data declaration via the "CBAM facility" would be appropriate, including clearing by the customs office.

Whereas in a system with actual EU ETS allowances exports could be supported by granting free allocation for the product (see similar considerations in Section 5.4.3), such free allocation of notional allowances would only make sense in CBAM designs where the notional allowances would be tradable. As recommended above, the EUIAs should be non-tradable, a refund for exports would have to be granted after data reconciliation during the "CBAM compliance cycle". In this process, the amount of notional allowance entitlement for each exporter would be determined, those allowances would be generated, allocated to the exporter, and immediately cancelled in exchange for a payment to the exporter based on the reference carbon price determined for the CBAM (see Section 5.1).

Note, however, that the precondition for such support would be that no free allocation is given to EU ETS operators, in order to avoid double support.

5.4.3 Surrender of EU ETS allowances (Option Pay.2)

How would it work?

This option would work in practice in a similar manner to Option Pay.1 as described in Section 5.4.2, in particular in relation to the "compliance cycle" and the way data is collected via the customs clearing process. The main differences would be as follows.

- The carbon costs faced by importers in the CBAM would be more comparable to those in the EU ETS, as the importer can better benefit from price fluctuations (buying at lower prices) and can apply diverse hedging options. Since Option Cycle.1 (immediate surrender of allowances at import) would not provide these benefits, it would not make sense to combine it with the use of actual EU ETS allowances. Hence, Option Cycle.1 is excluded for option Pay.2.

- The EU ETS Registry would not require any additional type of allowances. The allowances used would be completely tradable, as they would be indistinguishable from EUAs already in use now.

- There would be no need for the CBAM authority to sell allowances to importers. Instead, the existing auctioning platforms and marketplaces would be where importers buy allowances.

- There would be no need for the CBAM authority to determine a reference price for the allowances to be surrendered.

- A mechanism would be necessary for determining the annual amount of allowances required by the CBAM (i.e. the quantity by which the existing EU ETS cap would have to be adjusted in order to avoid a distortion of the CO_2 price signal compared to the non-CBAM scenario). If this cap adjustment deviates significantly from the actual demand created by the CBAM, the EU ETS reduction target provided by the cap would be missed. (see Section 5.8)

How would support for export work?

If Option 3 were to be implemented by "payment methodology" EU ETS allowance surrender, and if there were no longer free allocation for the sectors in the CBAM, then the support for exports (if applicable at all), could be easily integrated in the EU ETS by keeping the existing free allocation rules in place, the only difference being that the data regarding exported goods and not the total production levels would have to be reported to the CA. The current reporting rules would have to be supplemented by rules for providing evidence of the export. Note, however, that it will be quite difficult to determine fully and correctly the embedded emissions in case of value chains (see Section 5.2.3), for instance, if a steel producer has to assign emissions to the coke and sinter it purchases on the market. This might again be a situation where it would be necessary to define default values.

Should free allocation remain in place at least for a transition period (Option 2), no further action is needed for supporting exports (i.e. there is no room for a hybrid approach between Options 2 and 3). However, if the free allocation were phased out, for instance, by gradually reducing the percentage of free allocation, such a hybrid approach might be used, which grants the gradually reduced allocation to the total production, and adding a higher percentage for exports, simulating the situation described in the previous paragraph.

5.4.4 Tax upon import (Option Pay.3)

How would it work?

In terms of implementation, this Option Pay.3 would be the simplest of the three payment modalities discussed, as no connection to the EU ETS Registry and no additional mechanism regarding allowance creation would be required. If used in combination with allowing only the use of default values for the embedded emissions, it would be as simple to implement as a normal import duty, i.e. the obligation would be calculated at import and immediately paid before the customs office clears the import . It would be implemented solely by using Option Cycle.1.

The only reason for data reconciliation at a later stage would be if an investigation finds incorrect declarations regarding the type of product imported or its origin (for instance, if different carbon pricing systems in other countries are taken into account in determining the amount of the CBAM obligation).

However, if the CBAM design allows the importer to use actual embedded emissions values, it requires design Option Cycle.3, i.e. a hybrid combining Cycle.1 with the compliance cycle under Cycle.2. The advantage of the immediate payment under Option Cycle.1 would be that the importer can never pay too little (if the actual monitored embedded emissions were higher than the default value, the importer would be allowed to use the default value). Furthermore, it is assumed that the vast majority of importers would rely on default values for their simplicity. Thus, they would gain legal certainty of compliance quickly.

Only for the few cases where importers declare actual monitoring data, a reconciliation during a compliance cycle would be mandatory. The system under Cycle.3 would therefore require a smaller staff of the competent authority for checking emission reports and verification reports. When the CA is satisfied by the existing data, they would recalculate the CBAM obligation of the previous year. Where an importer's CBAM obligation is lower than already paid upon import, the difference would be reimbursed.

The recommendation for implementing Option Pay.3 would be to use Cycle.1 in combination with mandatory default values or using a Cycle.3 design if actual emissions data is allowed.

Further differences to payment methods using allowance surrender would be as follows.

- It would be mandatory to have a reference carbon price defined. Of the options discussed in Section 5.1, the simpler options (annual average price determined by the CBAM authority) would be preferred over, for instance, daily adjusted prices. This would provide simpler implementation and greater predictability for importers.

- The tax level based on the applicable carbon price and the default values for embedded emissions can be easily handled in the TARIC[121] database. The applicable carbon price would have to be regularly updated in that database.

- However, the importer (or the customs office) would still have to enter the relevant data into the CBAM facility, as the revenues have to be kept separate from other duties at MS level. It is also mandatory in case data reconciliations are envisaged.

How would support for export work?

As already stated for the other payment modalities (Sections 5.4.2 and 5.4.3), support for exports under main Option 3 is only applicable, if there is no free allocation under the EU ETS, since the latter is considered effective for mitigating the relevant carbon price differences between EU and foreign producers.

If free allocation is no longer available, support for exports would require a system of data collection mirroring the import system (see description in Section 5.4.3), i.e. collecting relevant export declarations in the CBAM facility when a good leaves the EU. A financial value for reimbursement to the exporting EU ETS installation would be determined based on the applicable carbon price and a default value for embedded emissions which is in principle comparable to the amount of free allocation which would be given in the current EU ETS design. As this would require annual emission monitoring data, the reimbursement for exports would have to be granted following a compliance cycle-like reconciliation process (Option Cycle.2).

5.5 Interim conclusions on implementation

In Sections 5.1 to 5.3 we have provided a multitude of options for calculating the obligations under a CBAM for the main Options 1-3 and, to a lesser extent, main Option 4. We have also discussed different ways in which payment can be effected (i.e. surrender of notional or EU ETS allowances, or a tax on imports). All in all, the most important impact on the design of the CBAM comes from the three following parameters.

- The modality of the "payment": Options Pay.1 (notional allowances), Pay.2 (EU ETS allowances) and Pay.3 (tax) as described in Section 5.4.1. For Pay.1, three sub-options are

[121] https://ec.europa.eu/taxation_customs/business/calculation-customs-duties/what-is-common-customs-tariff/taric_en.

defined in Section 5.4.2 regarding how the notional allowances could be treated: NoA.1 (non-tradable), NoA.2 (tradable), and NoA.3 (using an automatic issue/surrender mechanism).

- The type of "compliance cycle" to be used (see Section 5.4.1): Option Cycle.1 means immediate "payment" (or surrender of allowances) for each import, Cycle.2 would be more like the EU ETS's compliance cycle, i.e. once a year there would be the reconciliation of data concerning the imports of the previous year and "payment" following thereafter, and Cycle.3 would be a hybrid approach: immediate payment, but nevertheless reconciliation after one year (this would be more like an error correction mechanism only).

- What kind of data is used to calculate the obligation to be paid for the CBAM (Section 5.2.6): Option DV.1 would rely exclusively on default values for embedded emissions of imported goods, while Option DV.2 would mean that the importer may use actual emission data provided (voluntarily) by the producer of the imported goods. Where such emission data is unavailable, the default values would be used. Note that we have not considered a third option, which would be to require actual emissions data mandatorily, as this unrealistic.

The combination of these three parameters gives the following result for **overall implementation designs** for the CBAM:

Option Number		Cycle.1	Cycle.2	Cycle.3
Pay.1 - notional allowances	DV.1	preferred (NoA.3)	possible (NoA.1)	possible (NoA.1)
	DV.2	not useful	possible (NoA.1)	preferred (NoA.1)
Pay.2: EUAs	DV.1	possible	preferred	possible
	DV.2	not useful	preferred	possible
Pay.3: Tax	DV.1	preferred	possible	possible
	DV.2	not useful	possible	preferred

For implementing a CBAM, it is furthermore necessary to define which carbon price should be used. Section 5.1 provides several options for this purpose, with CP.1 being the least accurate option, and CP.5 the one that correlates best with the EU ETS. The preferred option is based on a reasonable balance of accuracy against administrative complexity. The options can be linked to the payment options above as follows.

Carbon price option	Pay.1	Pay.2	Pay.3
CP.1: Uniform carbon price for the whole EU ETS trading period	not useful	n.a.	not useful
CP.2: Uniform carbon price determined once a year	possible	n.a.	possible
CP.3: Uniform carbon price determined once a month	preferred	n.a.	preferred
CP.4: Daily actual allowance price (based on the previous work day)	possible	n.a.	possible
CP.5: Actual market price	n.a.	applicable	n.a.

At the very core of making the CBAM feasible in practice is the MRV system. First of all, it is necessary to define what kind of emissions should be covered. While it is clear from the outset that the "embedded emissions" should correspond to emissions which result in carbon costs under the EU ETS, there have been three factors defined in Section 5.2.3 leading to options for the definition of "embedded emissions". Section 5.2.4 gives options for the MRV approach which exactly correspond with the embedded emissions options. The three key questions are as follows.

- Are the carbon costs in non-EU countries taken into account?
- Is the value chain taken into account (i.e. are the embedded emissions of previous production steps in the value chain added to the embedded emissions of the imported good)?
- Are indirect emissions (i.e. from the production of electricity consumed in the process) taken into account?

These three parameters can be combined into eight options as follows, with Option EE.1/MRV.1 being the most ambitious and encompassing one:

Option Number	Carbon costs taken into account?	Value chain taken into account?	Indirect costs taken into account?
EE.1 / MRV.1	Yes	Yes	Yes
EE.2 / MRV.2	Yes	Yes	No
EE.3 / MRV.3	Yes	No	Yes
EE.4 / MRV.4	Yes	No	No
EE.5 / MRV.5	No	Yes	Yes
EE.6 / MRV.6	No	Yes	No
EE.7 / MRV.7	No	No	Yes
EE.8 / MRV.8	No	No	No

The preferred option in terms of environmental effectiveness and general climate ambition is EE.1 / MRV.1. However, it is the most challenging in terms of MRV requirements and administrative burden. Lower ambition options can be chosen if EE.1 / MRV.1 is found not feasible in practice. Note that some of the less ambitious options above could, in some cases, lead to double pricing of parts of the value chain, as an assessment of the interaction between EU ETS and CBAM shows (see Section 5.8).

Finally, a crucial element for the CBAM is the definition of the default values that will be used to calculate the CBAM obligation on imports. Firstly, in the chapter on scope (Chapter 4) we discuss whether a material or product should only be included in the scope of the CBAM if the definition of the default value for embedded emissions is possible. This feasibility criterion strongly depends on the definition of "embedded emissions". However, it also depends on the methodology chosen to determine reference default values. This is discussed in Section 5.2.5. The options proposed are:

- Option MRV.Def.1: Default values are to be determined by data collection by EU ETS installations; and
- Option MRV.Def.2: Default values are determined by other means, such as literature studies and an expert group.

Although MRV.Def.1 would result in more reliable data, the related administrative burden for EU ETS operators seems excessive. Therefore, option MRV.Def.2 is preferred, although the resulting default values may be more susceptible to challenge by stakeholders (both inside and outside the EU).

5.6 How to implement an excise duty (Option 4)

Beyond raising revenue (Cnossen 2020), excises generally are a natural way of correcting for damages that arise from the use of the commodity in production as well as in final consumption (Crawford et al. 2010, 317). In contrast to previous proposals for introducing carbon excises in Europe (Smith and Vollebergh 1993), the present discussion on introducing an excise on carbon-intensive materials has to be seen against the background of the EU ETS, which it is meant to complement, but not to replace. In other words, given that the excise is not intended as a fundamental alternative to an emissions trading system, it follows that the design of the excise should be such that it ensures complementarity with the EU ETS (Ismer et al. 2016). At the same time, design choices should also bring to bear the age-old experience with excises in general and the legal framework created by the EU Excise Directive in particular. The latter point applies irrespective of the exact legal form of the excise – it can, as will be shown in the following, take three potential technical approaches for implementing the excise (EU excise; harmonised excise and consumption charge).

5.6.1 Calculation of excise liability

There are generally two main methods of charging excises, namely specific rates, based on quantity, and rates based on value. The excise liability proposed here would follow the first approach. It would thus be calculated by applying the relevant carbon price to the base of assessment.

Embedded emissions as the basis of assessment

The embedded emissions as the basis of assessment would be the quantity of the carbon-intensive material produced or imported multiplied by a carbon intensity factor. The latter would represent an irrefutable value, so that only default values are used for embedded emissions of imported goods. The carbon intensity factor should reflect the carbon content of each material covered. In order to ensure administrative feasibility, the carbon content should not reflect the specific production processes of the specific material at hand, but should be determined according to material-specific reference values. Initially, such reference values could, where available, correspond to the EU ETS product benchmarks already used for free allocation of allowances. The EU ETS benchmarks, which are based on emissions of the 10% best-performing installations in the European Union (Article 10a(2) of the EU ETS Directive), are independent of the actual production process. Such equivalence is, however, not absolutely necessary. The basis of assessment could also differ from free allocation.

Relevant carbon price

The relevant carbon price should be determined by the allowance price at the EU ETS auction platform. At first glance, similar considerations apply as under Options 1 to 3, which have been discussed above in Section 5.1. In theory, the carbon price could again be determined for different periods. It could reflect the (near) real-time price of allowances at the carbon markets at the time of production or importation. There could be a daily (or possibly monthly) reference price. A permanent real-time adjustment would entail high administrative and compliance costs for the government and the companies involved. More frequent updating implies in particular that timing issues become more important: did the chargeable event occur before or after the rate change? While this should be feasible in theory, it must also be seen that this entails the need for corresponding documentation. It therefore appears preferable to apply a yearly average carbon price as, for example, revealed by the trade-weighted clearing price of allowances in public auctions. The exact figure could, for example, be published by the European Commission together with other yearly adjustments made in the trade context.

5.6.2 Timing of the excise: duty suspension

The excise should, in line with standard excise practice, contain a duty suspension mechanism (cf. Jatzke 2012). This mechanism differentiates the time when a liability to the excise is created from the time when it becomes payable (due). The excise could either be imposed when carbon-intensive materials are produced, imported, or when the respective carbon-intensive materials are supplied to final consumers. Both approaches have significant disadvantages. When the excise is levied at the time of production or importation, the charge would have to be refunded upon exportation. Such refunds, which would not necessarily be granted to the actors that had paid the charge in the first place, are, as VAT and excise fraud shows, open to fraud. Moreover, there would be a risk of excess refunds when the charge rises over time. When the excise is only applied at the time of supply to final consumers, the authorities would have to monitor a huge number of participants in the scheme with corresponding administrative costs. This task would be complicated by the fact that the audit and invoice trail would be poor.

The duty suspension mechanism as a hybrid of both types makes it possible to avoid the drawbacks of both approaches by differentiating between the creation of the liability ("taxable event") and the moment when the liability actually becomes due ("chargeability of the tax"). Duty suspension arrangements are fiscal arrangements which suspend the excise. The liability to the charge is created on production, but the charge is not due as long as goods are held under such arrangements. Duty suspension arrangements allow authorised entities to produce, process, hold, transport and trade excise goods between producers of different production stages without triggering excise. The duty is transferred along the supply chain until excise goods are finally released for consumption or when shortages are recorded. According to Article 7(2) of the EU Excise Tax Directive, release for consumption is deemed to occur when excise goods depart from suspension arrangements or are held, produced or imported outside such arrangements, and duty has to be paid. All this means that the occurrence of the taxable event does not necessarily coincide with chargeability of the tax.

In addition to avoiding the disadvantages of both the approach which taxes at the time of production or importation as chargeable events, and the approach which creates the tax liability only upon release for consumption, the duty suspension mechanism has the advantage of adequately dealing with recyclable return flows from offcuts in the production process: the liability could in such event be acquitted, i.e. cancelled, even if it occurred at a later stage in the value chain than the production of the material, but prior to release for consumption. Moreover, the duty suspension arrangement defers the payment of the liability and thus avoids an excessive burden that could arise if the liability were due without any corresponding cash flow (Terra 1996, 254).

The set of authorised entities should, however, be limited. The authorisation requirement ensures that the economic agents meet their obligations. In particular, they have to effectively pay any charge due which they owe. At the same time, economic agents are given the choice whether they want to participate in the duty suspension scheme so that they can balance the ensuing compliance and administrative costs with the advantages of such participation, in particular with respect to excises.

5.6.3 Person owing the excise

In line with the rules provided for in the EU Excise Tax Directive, the excise would initially be owed by the person producing the relevant material. In the case of importation, the liability would be owed by the person who declares the excise goods or on whose behalf they are declared on importation. Both in the case of production and of importation, the liability could be passed on to another registered entity, as long as the materials or goods containing the materials are held under duty suspension. The excise must be paid by the person releasing excisable goods from duty suspension arrangements. At the latest, this is the seller in a transaction to the final consumer; it can, however, be an economic operator further up the value chain, when the material or product containing the material leaves the duty suspension arrangement. In the case of irregular production or importation, the liability would also be owed by any other person involved in the production or importation.

5.6.4 The international dimension

The excise should have an external interface in the form of a carbon border adjustment mechanism. This would make sure that carbon-intensive materials covered by the excise that are consumed in the European Union would be subject to the same carbon pricing through the excise as domestically produced materials. The excise would thus be, as is regularly the case for indirect taxes (Terra (1996), 248), implemented in accordance with the destination principle. Under the destination principle, tax is ultimately levied only on the final consumption that occurs within the taxing jurisdiction. Under the origin principle, by contrast, the tax is levied in the various jurisdictions where the value was added. At the same time, only consumption in the European Union would be covered by the excise, but not consumption outside the EU. For that purpose, exports would be relieved of the charge, whereas imports would be subject to the excise at a level reflecting their content of carbon-intensive materials.

In Section 2.12 of its International VAT/GST Guidelines, the Organisation for Economic Cooperation and Development (OECD) has also pointed to the advantages of indirect taxation in accordance with the destination principle. It stated:

> “VAT systems are designed to apply in a fair and even-handed way to ensure there is no unfair competitive advantage afforded to domestic or foreign businesses that may otherwise distort international trade and limit consumer choice. This is achieved by the application of the destination principle, under which exports are free of VAT and imports are taxed on the same basis and at the same rate as domestic supplies. The destination principle ensures that the net tax burden on imports is equal to the net tax burden on the same supplies in the domestic market. In addition, it also ensures that the amount of tax refunded or credited in the case of exports is equal to the amount of tax that has been levied.”

The relief for exports would follow automatically for materials and goods held under duty suspension arrangements. Upon exportation, the liability to the charge would be acquitted. Thus, the charge, which was created upon production, would not come due. This would also apply to cases where the liability has been transferred under a duty suspension mechanism after it has been created. However, there would be no relief for goods that were not held under duty suspension arrangements, because in their case release for consumption had already occurred. The excise would not only have been created, but it would also have become due. Since there are no refunds for excises after release for consumption – there is no possibility of taking back release for consumption or taking them back into duty suspension – the excise would be final.

Conversely, the importation of covered carbon-intensive materials would be covered by the excise. Imports would be subject to the excise according to the content in the relevant basic materials, the emissions reference value and the applicable rate.

The scope of imported goods giving rise to the charge should not be limited to the scope of basic materials covered by the excise on production. Such a limited scope would be too narrow, as carbon embodied in the trade of goods down the value chain would be ignored. It should be wider and encompass not only materials, but also basic material products, semi-finished and manufactured products to the extent they contain the carbon-intensive materials that are subject to the excise – just as it would if a domestic product was produced with carbon-intensive materials in the European Union.

The scope of imported goods giving rise to the liability should not be too wide, in order to limit administrative and compliance costs. However, *de minimis* rules would imply that the excise should apply only to the importation of goods in pre-defined product categories which have an elevated content of carbon-intensive primary materials. The product categories could be chosen based on the share of carbon costs relative to the product value. Pauliuk et al. (2016) have found that restricting the creation of liability upon import to around 1 000 product categories of the Harmonized Commodity Description and Coding System (HS) would still allow coverage of around 85 per cent of imported emissions associated with carbon-intensive material. Moreover, the importation of small quantities could be exempted in line with current customs rules.

As for the case of domestic production, imports could also be held under a duty suspension arrangement. The excise would then be suspended until the release for consumption.

5.6.5 Monitoring and verification requirements

As duty suspension arrangements allow for the transfer of liabilities along the value chain, efficient control mechanisms need to be in place in order to ensure that no liabilities are acquitted unlawfully. At the same time, administrative and compliance costs must not be excessive.

Producers of carbon-intensive materials (both domestic and non-EU) subject to the excise would have to account for the mass of materials covered by an excise. The production volumes would have to be reported to competent authorities, e.g. on a quarterly basis. At least in case of EU ETS installations, some of these data would correlate (but not be identical) to data used for the determination of the free allowance allocation. Hence – if the same competent authorities were involved – under-reporting would be unattractive for these operators, as it would not only reduce the liability under the excise but could also affect the free allowance allocation in the EU ETS. A certain degree of compliance control by the competent authority would still be required.

When moving carbon-intensive materials under duty suspension, authorised persons would have to account and report on the trade flows of ingoing or outgoing carbon-intensive materials. This would encompass the mass and basic material type (e.g. steel, cement clinker) and mean that the corresponding liabilities transferred would have to be respectively assumed. The trade flows and liabilities would then have to be assessed and confirmed by the competent authorities. Again, the conflict of interest between the supplier and the recipient implies that the intensity of performing checks would not have to be very high. A clearance system, along the lines of the one in operation under current Italian VAT rules, could also help. Under that system, input VAT credit can only be requested when the transaction has been registered on servers of the Italian revenue agency and the transaction has been cleared. As a consequence, VAT fraud has been reduced dramatically at what seems to be relatively minor compliance costs.

On release for consumption, the authorised persons would have to account for and report on the weight of carbon-intensive material released for consumption, as well as on the amount of excise to be paid.

On importation and exportation, authorised persons would have to report on the corresponding weight and types of carbon-intensive materials. This information would form part of the customs declaration documentation. Confirmation of the weight of basic material or bulk products would be fairly straightforward, as the total weight of the imported product is already stated on the customs declaration and the weight of carbon-intensive material could be derived from this information. For intermediate and final products, the information provided by producers could be verified with reference to product category-specific material reference values reflecting the average carbon-intensive materials content of a product category, provided they can be determined and agreed in the relevant fora.

5.6.6 Legal form

As already indicated, there are three potential technical approaches for implementing the excise. It may either take the form of a new tax to be levied by the European Union or a harmonised tax to be levied by Member States or finally a consumption charge that would be accessory to the EU ETS. The different legal forms have implications for EU competence to adopt the measure as well as for the procedure to be taken and the majority requirements, i.e. in particular the question whether the measure can only be adopted with unanimity. It will be shown that an EU excise would be a legal innovation. By contrast, the adoption of a harmonised excise could follow in the footsteps of previous harmonising measures in the field of excises, in particular of the EU Excise Directive. Its adoption would require unanimity in the Council unless the passerelle clause of Article 48(7) TEU were to apply. Finally, the consumption charge could be passed with qualified majority voting as it would represent an environmental measure which is not primarily of a fiscal nature.

- **European Union excise**. Article 311 TFEU governs the own resources of the European Union. There are no explicit statements on the admissibility of taxes levied by the European Union. The European Union currently does not levy taxes or excises beyond customs duties. There is, however, a wide-spread discussion about whether the own resources should include European Union taxation (Dussart 2012; Kube 2017; Traversa and Bizioli 2020; Häde 2017, m.nos. 50 ff.). In particular with respect to the current COVID-19 crisis, calls have been made to pave the way for such taxes. It is currently not clear whether the European Union could under current rules levy taxes. In any event, this would require unanimity by Member States.

- **Harmonised Excise**. Member States could alternatively agree upon the harmonised introduction of excises. The environmental motivation of the excise would imply that Article 192 could be invoked as the legal basis. Unless the passerelle is triggered, this legal basis will require unanimity in the Council. The result would then be an excise introduced in all Member States of the European Union.

- **Consumption charge accessory to EU ETS**: The consumption charge could be designed in a manner that it would not constitute a measure that was not primarily of a fiscal nature in the sense of Article 192.2(a) TFEU (on this, see Ismer and Haussner 2016). This is because the consumption charge would form an integral part of the EU ETS as it would: pursue the same objectives (reducing emissions); use the same means (incentivising an efficient use of carbon-intensive commodities by cost allocation); yield the same results as full auctioning, which is the basic principle of allocation under the EU ETS; and put domestic and foreign products on an equal footing – just as foreseen by the EU ETS Directive. In addition, the combination of free allocation and the consumption charge would remedy the current inefficiencies of the EU ETS. The reasoning that the EU ETS was not based on 'provisions primarily of a fiscal nature' and thus did not require unanimity in the Council, can therefore also be applied to the inclusion of consumption. Instead, the qualified majority under Article 192.1 TFEU would be sufficient. Moreover, the revenue raised could be used in a manner that would reveal a close connection to the general EU ETS. Finally, the amount to be paid by the chargeable person would be closely linked to the EU ETS as it would depend on: (i) the market price of EU ETS allowances; and (ii) the same reference values which may have some similarity with EU ETS product benchmarks. Moreover, even if the charge could not be considered an integral part of the EU ETS, Article 192.2(a) TFEU would still not apply as the measure is arguably not primarily of a fiscal nature.

5.7 Analysis of the possibility of rebates based on climate policies in third countries

The rationale of a CBAM is to offset the disadvantage that domestic companies have due to more ambitious domestic climate policies vis-à-vis their competitors from other countries with less ambitious climate policies. Thus, the CBAM should close the relative gap between the actual carbon constraints imposed in the home country and that of the trading partner, as far as these policies apply to the industries / processes in question.

This suggests that, ideally, the level of CBAM would differentiate between different trading partners, depending on the level of ambition of their climate policies, as they apply to emissions from the industries in question: countries with lower ambition would face a higher CBAM; those with higher ambition a reduced one. Countries whose ambition would be deemed equivalent or even higher than that of the domestic regulations would be entirely exempt from the application of the CBAM – as there would be no relative gap to be closed.

Depending on how the CBAM is implemented, there different options below illustrate how the (partial) exemption could be implemented in practice (see 5.4.1).

- For a tax paid at the border (Option Pay.3), the tax rate would be differentiated per country – and possibly per industry – so that the applicable tax rate would only cover the difference between the EU carbon price (i.e. the EUA price), and the effective carbon price applicable to emissions from the respective industry in the respective country.

- For options where the importer is required to surrender (notional) allowances (Options Pay.1 or Pay.2), the fact that the embedded emissions of the imported goods were already covered with a carbon price (or an equivalent effective carbon constraint) can be taken into account in two ways: Either the importer would receive a certain amount of free allowances, or the emissions already covered by a carbon price would be deducted from the CBAM obligation. The deduction in both cases would correspond to the relative stringency of the carbon constraint in the source country – i.e. a country whose effective carbon constraint is considered to correspond to 60% of that of the EU would receive free credits corresponding to 60% of the embedded emissions.

5.7.1 Options for assessing climate policy efforts in third countries

While it is convincing in theory that a CBAM should reflect the difference in climate ambition, there are several challenges related to this approach. The most crucial ones hinge on the definition of climate ambition, and the metric applied to measure it. Three general options could be considered here (compared to the baseline case ClimPol.0, in which there is no differentiation).

- **Option ClimPol.1**: the overall climate ambition of a country, as reflected in its international commitments and obligations (in particular its Nationally Determined Contribution (NDC)),

- **Option ClimPol.2:** the enacted climate policies applicable to emissions from industry, or

- **Option ClimPol.3:** more specifically the carbon price applicable to emissions from industry.

These options are discussed in the following.

No differentiation (Option ClimPol.0)

In this baseline case, there is no differentiation according to climate policies in the respective countries, i.e. the full level of the CBAM applies to all relevant trade with all countries that are not part of the EU ETS.

Nationally determined contributions (Option ClimPol.1)

An obvious reference point would be national climate targets, as expressed in the NDC. One clear advantage of this approach is that it provides a clear, firm, legally established point of reference to measure the climate ambition. There are, however, several drawbacks and constraints to this approach (Görlach and Zelljadt 2019).

- First, what matters for the actual leakage risk is not the declared ambition of national climate policies (as expressed in the NDCs), but the actual carbon constraints that are imposed on emitting activities – and while the two should of course be equivalent in theory, i.e. instruments that match the ambition of the target, they are likely to diverge in practice.
- Moreover, different NDCs use vastly different metrics and types of targets, from absolute emission targets to intensity based, technology or sector-specific targets; in addition, the existing targets are often contingent on international support, or on other countries taking similar steps. Think tanks, research institutions and NGOs have established indicator systems that track and rate the ambition expressed in NDCs, but these are also illustrative of the limitations and the judgements calls needed in order not to transfer a complex set of targets and instruments into a single measure of climate ambition.
- Third, only few NDCs explicitly define the level of ambition for broad economic sectors (such as industry vs energy), be it in terms of sectoral mitigation targets, sectoral mitigation policies, or through sectoral mitigation plans and programmes. Let alone for specific industries such as steel or cement – yet this is the level of detail that would be needed to assess the relative stringency of efforts in relation to the leakage risk. Among the G20, Japan is the only country that specifies at least some activities at the level of individual industries as part of its NDC.

A variant of this approach would be to distinguish between Annex-I (AI) and Non-Annex-I (NAI) countries in the application of a CBAM. This has the advantage of being based on a clear-cut, legally established distinction. As an Annex to the UN Framework Convention on Climate Change, the Annex and therefore the categorisation of countries remains legally valid.

The question is, however, whether this distinction still has practical relevance, and whether it would be appropriate and useful. The Paris Agreement has avoided any reference to AI and NAI-countries, and instead differentiates between developing and developed countries. In doing so, it introduced even more differentiation between countries and their respective circumstances and capabilities, and thereby sought to move beyond the old dichotomy, with its binary, static distinction of countries into AI and NAI. Not least because overcoming the dichotomy was one priority of the EU, it would therefore be bizarre to move back to the old world, and to base EU policies on this distinction.

Furthermore, in practice, the group of Annex I countries is by no means composed of like-minded countries with equally high ambition, as Annex I status has played out very differently for different countries. There are Annex-I countries that never had reduction targets under the Kyoto Protocol (KP) to begin with, as they were part of AI but not of the Annex B to the Kyoto protocol. Others have formally left the KP, or have publicly announced that they do not intend to follow up on their Kyoto commitment, and some have just missed their reduction targets without drawing consequences, or have not signed up to the second commitment period of the Kyoto Protocol. And, finally there are those that have remained true to their KP targets – but which had targets far in excess of their baseline emissions, and as a result essentially did not need to take any action. At the same time, there are at this point several Non-Annex-I countries – including large emitters – that are displaying relatively high ambition, be it in their commitments, or in the domestic climate policies actually implemented, or both. Therefore, AI vs NAI status is a relatively poor measure of a country's commitment to climate action, let alone the actual carbon constraints imposed on its domestic industries.

Enacted climate policies applicable to industry (Option ClimPol.2)

Beyond the NDCs, a second possible point of reference could be to assess the enacted climate policies that are applicable to different industry sectors. A conceptual problem here is that, from the CBAM perspective, this comparison would need to focus exclusively on the stringency of climate-related regulations. Yet in practice, the lines between regulation that was introduced to protect the climate, and regulation that pursues other related objectives – energy efficiency, energy independence, air quality improvements, innovation or technology leadership – are often blurry. As a matter of fact, the capacity of policies to deliver on multiple objectives would typically be seen as a benefit. Whether and to what extent countries emphasise the climate aspects of regulation, or other aspects, will often depend on regulatory tradition, political opportunity and the domestic policy discourse. Thus, for instance, India or South Korea have a long tradition of regulating energy efficiency and industry; as a result, energy efficiency instruments also feature prominently in their climate-related portfolio of instruments. In other jurisdictions, if climate policy is particularly contested, it is politically expedient (or necessary) to re-label any climate policies by emphasising the non-climate benefits and putting them in the foreground.

In the European context, this is mirrored (albeit in the transport sector) in the discussion on energy taxes vs carbon taxes – which are functionally equivalent for all intents and purposes, but have been introduced with different labels and different intent (if and where the intent is specified). Yet, since energy taxes (mostly in transport) outrank the explicit carbon taxes by a factor of ten in the EU, the distinction is indeed a crucial one.

Besides these conceptual issues, there are severe practical challenges involved in comparing the stringency of non-price policies. For instance, energy efficiency standards in different jurisdictions will typically differ in terms of the processes, technologies or subsectors to which they apply. They often use different specifications that are not directly comparable, e.g. different metrics for energy efficiency, or they are defined for different target years, and have vastly different compliance mechanisms. For this reason, existing international comparisons of energy efficiency or air quality standards typically merely list which standards or other regulations can be found in which countries but stop short of assessing their actual stringency.

Carbon prices applicable to industry (Option ClimPol.3)

The most straightforward approach is therefore to compare only the carbon prices that are applicable to emissions from the industry sectors in question, irrespective of whether these are levied through a carbon tax or an ETS. There is an inherent logic to this approach, in that the CBAM is tied to a pricing instrument in Europe, and therefore seeks to address the differences between the EU ETS and other carbon pricing tools.

The obvious advantage of this approach is that carbon prices themselves are relatively easy to establish and to compare. Transparency on carbon prices differs, particularly when deep-diving into issues of where a price specifically applies to particular subsectors or installation types, but by comparison the data available is reasonably good and up-to-date.

However, to date, carbon pricing mechanisms applied to industry consistently have been accompanied by tax exemption and rebates or free allocation of allowances. Hence the effective carbon price to be considered, would need to be corrected accordingly.

However, for the comparison of the carbon price level and adjustments for exemptions, there are also a number of conceptual and practical issues to resolve. On the conceptual side, one challenge is that the carbon price can take different roles and functions in the domestic instrument mix. Given their regulatory history, their legal setup and their economic and governance structures, different countries chose to regulate through different instruments – and market-based instruments such as the carbon price tend to be most effective and suitable where they coincide with a generally market-oriented approach to regulation also in other regards, e.g. in the form of liberalised energy markets and least-cost dispatching (Hood 2011).

On a more practical note, a comparison of carbon prices will need to overcome several difficulties. For instance, the coverage of industries and the delineation of the emissions covered may diverge. This is apparent, for instance, in the case of South Korea, where the ETS coverage diverges in two important respects: first, the compliance obligation rests on the firm, not on the installation, and thus also comprises multiple smaller emissions sources within the firm’s perimeter that would not be covered by the EU ETS. Second, the coverage also includes indirect emissions associated with electricity generation. Third, a comparison that only looks at the price will overlook important differences in implementation aspects - carbon pricing mechanisms applied to industry consistently involve tax exemption and rebates or free allocation of allowances. Therefore, a full comparison would also need to consider things like the design of allowance allocation rules, the stringency of allocation benchmarks and other key parameters, the extent to which companies can use offsets (and which types of offsets) to fulfil their compliance obligations, to the quality of monitoring and enforcement. Finally, as mentioned above, a comparison that only focuses on explicit carbon pricing instruments is bound to overlook the possibly substantial differences in taxes levied on energy used. Taken together, these parameters can mean that even a relatively high carbon price does not necessarily impose a significant cost on emitters, for instance, if they receive generous free allocation, or if the compliance and enforcement system is weak.

Apart from these conceptual and practical challenges, another consideration to keep in mind is that there are in fact very few instances outside the EU ETS where an explicit carbon price applies to industry emissions. While there is a large and growing number of carbon pricing mechanisms in the world, not all of them cover industrial GHG emissions and those that do are predominantly sub-national systems. Thus, industry emissions or parts thereof are covered in California, Nova Scotia and Quebec, in Switzerland, Korea and New Zealand, in the Japanese municipal systems in Tokyo and Saitama, and in some of the Chinese pilot systems (International Climate Action Partnership (ICAP), 2020). The forthcoming Chinese national ETS is also expected to cover some industry sectors at a later stage. In addition, in some instances national carbon prices also cover industry (e.g. Norway) (OECD, 2018).

5.7.2 Other practical challenges

Irrespective of which metric should be used for the assessment, there is a host of practical issues that would need to be resolved for comparing countries’ climate ambitions, including the following.

- **Authority and data sources.** The EU would need to assess the stringency of the climate policy efforts of trading partners. This raises the question of who should conduct the assessment, based on which data? Currently, it is either academic institutions or think tanks without government affiliation that assess and compare climate policies, or intergovernmental bodies such as the OECD, the World Bank or the ICAP. Such assessments often rely on a broad range of information sources, including academic and other publications, rather than official sources only. An assessment that only relies on officially reported data (e.g. submitted to the UNFCCC as part of their reporting obligations under the convention) would face the problem that such information is often delayed significantly behind the actual implementation, and lacks the necessary detail. In practice, to recognise the ambition of policies in third countries, the EU would have to enter into talks with every trading partner that has an effective carbon constraint, to agree on the terms of equivalence between the EU's policies and those of the trading partner.
- **Updating.** A related issue concerns the frequency of updating. In a rapidly evolving policy area, any assessments made would need to be reviewed and updated regularly (ideally annually or at least biannually), which suggests that a permanent structure would be required to monitor developments, and results in a regime with unpredictable obligations for foreign producers.
- **Level of assessment**. This poses the question as to whether an assessment should look exclusively at national level policies, or also consider sub-national policies. The US experience is particularly relevant in this regard as trends at these two levels can diverge substantially, but sub-national carbon pricing systems can also be found in Canada, China and Japan (ICAP, 2020). Consideration of sub-national policies provides a more complete picture of the actual carbon risk, but multiplies the data requirements, and compounds other issues such as, for instance, the fact that sub-national jurisdictions do not report their activities under the UNFCCC or other intergovernmental mechanisms. It also creates the risk of sub-national trans-shipments, e.g. if steel produced in another US state was first shipped to California, to be exported from there as a Californian product (and thus potentially benefiting from a reduced CBAM tariff.
- **Compliance gap**. the decisive factor for the leakage risk is not the announced policy effort, but rather the actual carbon costs that results from the policies actually implemented. Divergences between the two – implementation and compliance deficits – are common in reality, but are virtually impossible to assess in a reliable way.
- **Justification**. If the EU should decide to accept only certain types of regulation as equivalent (e.g. only carbon pricing systems qualify), or impose other qualifications (e.g. only mandatory cap-and-trade systems are eligible), the EU's trading partners could perceive this as interfering with their instrument choice.

5.7.3 Options for full CBAM exemptions

The previous discussion concerned the question whether it is feasible to exempt imports from certain countries pro rata from the application of the carbon border adjustment, in proportion to the stringency of their climate policy efforts relative to the EU, by either reducing their respective payment obligation (in Option Pay.3) or by providing them with free allowances or reduced surrender obligation in recognition of their domestic carbon constraints (Options Pay.1 or Pay.2). Another question is whether there could be a case for exempting certain trading partners from the carbon border adjustment altogether. Compared to the baseline option (EX.0 – No exemptions for specific groups), there are two obvious candidates in this regard, which are not mutually exclusive, i.e. can be combined.

- Option EX.1: a blanket exemption for imports from Least Developed Countries (LDCs), or
- Option EX.2: the exclusion of imports where the production is covered by cap-and-trade systems with a full link to the EU ETS.

No exemption (EX.0)

The baseline option would be to provide no exemptions to any country, or group of countries. This option is politically (and economically) problematic with respect to fully linked cap-and-trade systems, since it would impose a burden on imports from countries with whom the EU shares a common carbon price, i.e. which operate on a level playing field.

LDC exemption (EX.1)

One option for a full exemption from the CBAM could be Least Developed Countries (LDCs).

- On the one hand, such an exemption would be in line with and justified by the principle of Common but Differentiated Responsibilities, as established in the UN Framework Convention on Climate Change. Furthermore, there would be precedents for such a differentiation. Developing countries have benefited from trade preferences since the 1970s, whereby the EU, as well as other industrialised countries, have granted preferential terms and conditions. For instance, the EU under its "Everything but arms" initiative offers effectively zero tariffs to LDC trading partners for all products except arms and ammunition. As such, preferential treatment for LDCs is a long-standing practice that has been vetted by the WTO. It applies to a well-defined group of countries, on the basis of officially established and recognised criteria. There is also a precedent for preferential treatment of LDCs in EU climate policy. As of 2013, installations and aircraft operators covered under the EU ETS could use international certified emission reduction credits (CERs) only for projects started before 2013, while for projects registered in LDCs, the CERs remained eligible also for projects registered later than 2013.
- On the other hand, notwithstanding the precedent, this exemption would create an immediate *de jure* discrimination, which could be difficult to justify since all emissions contribute equally to global warming, irrespective of where they have been emitted. And unlike in the case of LDC exemptions in general trade agreements, which seek to encourage the growth of domestic production and processing capacities, neither the EU nor the trading partners would have an interest in fostering the growth of energy-intensive, high-emitting industries in these countries. The relevance of such an exemption would also be questionable, as LDCs currently account for a minimal share of EU-external trade in the commodities that could be covered by a CBAM. And finally, there are better alternatives to assist LDCs, in which the EU and other partners already engage, i.e. through technical assistance, technology transfer, capacity building and financial support. The EU supports in particular the development and deployment of climate-friendly technologies (and necessary infrastructure), both bilaterally and multilaterally, including through the mechanisms established under the UNFCCC (e.g. the Green Climate Fund).

Exemption for linked carbon markets (EX.2)

As a matter of consistency, countries with a carbon market that links to the EU ETS, and which covers relevant industry sectors, would need to benefit from an exemption. At the present time, this would apply to Switzerland. In terms of levelling the playing field, the linking of domestic ETS represents the gold standard. If different jurisdictions fully link their carbon markets, they share the same carbon price. Consequently, for all intents and purposes, the two would be considered as having an equally ambitious climate policy[122]. Therefore, any country or jurisdiction with a domestic ETS linked to the EU ETS would qualify for an exemption.

[122] This is also reflected in the wording of Art 25 (1a) of the EU ETS Directive, which allows linking only to "compatible mandatory greenhouse gas emissions trading systems with absolute emissions caps".

Beyond these obvious cases, a CBAM exemption could also be awarded to members of a "club" or an "alliance" (Keohane, Petsonk, and Hanafi 2017), i.e. to a group of countries that have committed to enact climate policies of similar ambition, and to cooperate in doing so, including through the exchange of information and adherence to certain minimum standards for the design and operation of their respective systems, possibly leading to a joint carbon market.

5.7.4 Summary evaluation

Recognition of third-party climate policies in a CBAM

Of the options considered above, the carbon price applicable to emissions from the industries concerned is the most feasible (or least infeasible) option to recognise the relative stringency of third-party climate policies in a CBAM. The carbon price (as it applies to industrial emissions) provides a unified, relatively robust and comparable metric. To the extent that the effective carbon price for relevant industries in other jurisdictions can be determined to a reasonable level (e.g. by means of an open policy dialogue with like-minded countries), it could be used to adjust the level of the CBAM obligation for various countries, where it can be justified as making environmental efforts comparable. In this way, despite some conceptual and practical limitations, the carbon price applicable to industry emissions can still provide a proxy for the ambition of domestic climate ambitions, and the effective carbon constraint that emitters in the respective industries face. Note that in Section 5.2.2 we present a potential calculation approach which takes into account the carbon price and even any free allocation given in third countries. This also demonstrates how difficult a detailed consideration of a carbon price would be.

Option Number	Practical feasibility
ClimPol.0 – No differentiation	Feasible
ClimPol.1 – NDCs	Not sufficiently differentiated
ClimPol.2 – Climate Policies	Not practical
ClimPol.3 – Carbon Prices	preferred

Full exemption from a CBAM

When exempting imports from certain groups of countries, a distinction is warranted between exemptions for LDC and exemptions for imports from linked carbon markets. In the case of fully linked carbon markets, exempting bilateral trade from the scope of a CBAM would be imperative in terms of consistency, since the climate policies in the linked carbon markets are equivalent by definition, and it could also provide a further, strong incentive for third-country ETS to seek a full link with the ETS. The case for an exemption is more debatable in the case of a blanket exemption for trade with all LDCs, as it could induce LDCs to move toward more energy- and emission-intensive processes.

Option Number	Incentive effect
EX.0 – No exemption	-/-
EX.1 – LDC exemption	Problematic
EX.2 – Linked ETS	Unproblematic

5.8 Assessment of the impact on the operations of the EU ETS

As the CBAM is envisaged to be a supplement to the EU ETS, it is important to assess the interaction between these two instruments. However, as the CBAM is only at the planning stage, with many variables still unknown, this assessment can only be of a qualitative nature. Where other chapters of this report have given options for the CBAM design, they are compared here, if relevant.

5.8.1 Coherence between CBAM and the EU ETS

The main question around coherence is whether there is any overlap between the CBAM and the EU ETS: At first glance, there is no overlap when considering main Options 1 to 3 (see Chapter 3). The EU ETS will cover the emissions of installations inside the EU, i.e. ensures that a price is paid for GHG emissions taking place during energy-intensive production processes in the EU. The CBAM, on the other hand, is intended to put a price on GHG emissions taking place outside the EU, but where the emissions are of interest to the EU, because the goods produced are used inside the EU.

However, with respect to the applicable rules in the CBAM, some overlap is desirable between the two instruments. The carbon price to be paid inside and outside the EU should be as comparable as possible. Therefore, system boundaries and MRV rules in general should be comparable for the determination of the emissions on which the carbon price is based and MRV rules for the CBAM should be based on those in the EU ETS (see Section 5.2). There should also be some coordination and information exchange between the respective competent authorities, and deadlines for the "compliance cycle" (if any is applied in the CBAM, see Section 5.2.7 and 5.3) should be coordinated.

If EU ETS applies to EU emissions and CBAM applies to non-EU emissions, and if the relevant "embedded emissions" for CBAM take into account the value chain of subsequent production steps, not only the last production step (Options EE.VC described in Section 5.2.4), then there might be some undesirable overlap, if MRV rules are not carefully designed. If for example Installation B (outside the EU) purchases ammonia from Installation A (in the EU), the carbon costs for the ammonia production have already been paid (in the form of surrendered EU ETS allowances). If Installation B then produces nitric acid and thereafter fertilisers using that ammonia, and the fertilisers then enter the EU again, the following situations may occur:

- CBAM uses MRV rules where only the fertiliser production step is considered (option MRV.VC.2). Only minimal embedded emissions are to be used to calculate the CBAM obligation (in fact they would be so small that fertilisers would probably not even be under the CBAM). But there would be no overlap between systems.

- CBAM uses option MRV.VC.1, i.e. the emissions of the production of ammonia and nitric acid would be part of the relevant "embedded emissions". The following options need to be considered.

    - Option DV.1 (exclusive use of default values, see Section 5.2.4): the CBAM obligation would be calculated using a default value for embedded emissions, which would include a share of emissions attributable to the ammonia production. This would mean that the emissions for the ammonia production would be priced twice, once by the EU ETS and once by the CBAM (notably not the exact same values, as one value would be actually monitored emissions, the other would be based on a default value).

    - Option DV.2: In this case, the operator of Installation B would have the possibility to provide voluntarily real emissions of its production processes. Installation B could aim at getting a lower CBAM obligation by using actual data. If Installation A is very efficient, Installation B can benefit from this, too. For quantifying the emissions of the ammonia production, there are two possibilities.

- MRV.CC.1 (see Section 5.2.4) provides for the possibility to deduct emissions for which a carbon price has already been paid. In this case Installation B would have to gather the information on actual emissions minus free allocation from Installation A. Alternatively, Installation B could use an EU-specific[123] default value, which in this option would take into account the EU ETS carbon costs.

- MRV.CC.2: The situation is the same as under the previous bullet point, except that the carbon costs cannot be deducted, therefore the emissions of ammonia production would again be double-priced.

The above demonstrates that implementing options have to be carefully chosen in order to make EU ETS and CBAM coherent in case of the main design Options 1 to 3. The preferred option for the definition of embedded emissions, Option EE.1 (see Section 5.2.4 and conclusions in Section 5.5) would ensure the required coherence.

Regarding Option 4 (excise), the assessment is easier: The excise would be an independent instrument added for giving products outside the EU a carbon price tag. However, there would not be any need to coordinate with the EU ETS, except that the EU ETS might provide some input into defining the reference values on which to calculate the amount of excise to be paid.

5.8.2 Impact on the EU ETS cap and carbon price

As some CBAM options involve the surrender of notional or EU ETS allowances, it can be expected that there may be an impact on the supply/demand balance on the EU ETS, i.e. an impact on the resulting carbon price. If and how this impact can be observed again depends on the exact implementation options of the CBAM.

- If **notional allowances** are used for main Options 1 to 3, implementation Option Pay.1, see Section 5.4.2 for a discussion of the three options, including how the notional allowances (termed "European import allowances", EUIA) can be handled in the EU ETS Registry, and how they would be linked to the market price of "normal" EU ETS allowances (EUAs). The conclusion is that the EUIAs should be non-tradable and might have an expiry date (or could be bought back by the CBAM authority if not used). If this preferred option were followed, there would be no direct impact on the scarcity and price of EUAs (with the exception of the generic impact explained under the last bullet point of this section). However, the same would apply to the other options for EUIAs. Their impact on the EU ETS cap or EUA price would be insignificant, since the markets would be kept separate, which is the very reason for using notional allowances in the first place.

- If **"normal" EU ETS allowances** (EUAs) are surrendered to fulfil the CBAM obligation, there could be an impact on the EUA market. In the absence of any further amendments to the EU ETS Directive, the CBAM on imports would mean that the cap is strongly tightened compared to the existing situation, because importers would have to purchase EUAs on the same market as EU ETS operators. The scarcity (difference between supply and demand) of EUAs would inevitably be increased, which in turn means emissions would become more expensive. Consequently, the need to reduce emissions within the EU ETS

[123] If carbon costs are taken into account, default values would have to be country-specific.

would increase compared to a scenario without a CBAM. If such cap tightening is considered desirable for optimal CBAM design, the "do nothing" option below would be appropriate. However, other options are possible for ensuring that the EU ETS cap would be affected less or even not at all. The following options could be used.

- Option Cap1 – "Do nothing". It would be accepted that scarcity in the EU ETS market is increased as mentioned above. The environmental impact would be favourable, because the incentive to reduce emissions would be quite strong for non-EU producers as well as within the EU, as the allowance price would increase fast. Politically, however, such a scenario can be expected to face strong opposition from industry. Furthermore, the formula "EU climate target = EU ETS cap + 27 MS ESR targets" would no longer be valid. The EUAs surrendered by importers for the purpose of the CBAM would have to be handled separately. Those EUAs would also not correspond to emissions occurring in the EU. Using this formula would mean that the GHG inventory used for UNFCCC purposes would show lower emissions than what would be allowed in the EU under the existing legal framework. Consequently, the "do nothing" option has to be excluded, although also for the other options it will be necessary to keep track of those EUAs that are surrendered by importers in order to exclude them from the GHG inventory system.
- Option Cap2 – "Try to get it right, simple (ex-post)". Under this option, a mechanism would be enshrined in the EU ETS legislation to adjust the cap to the new demand created by the CBAM as accurately as possible, e.g. by auctioning additional allowances e.g. monthly in the order of magnitude of the recent imports registered in the "CBAM facility" (see Section 5.4.1). As a result, the cap would be regularly increased, but the scarcity of allowances for producers under the EU ETS would remain more or less at the same level as without a CBAM. The carbon costs faced by EU industry would reflect an unchanged incentive for emission reductions. Therefore, this option appears to be the preferred one for ensuring the EU ETS continues to work in the absence of a CBAM. This mechanism would also work if the EU ETS cap is adjusted for the purpose of the increased climate ambition up to 2030, as the mechanism could be set on top of any existing cap given in the EU ETS Directive.
- Option Cap3 – "Try to get it right, *ex-ante*". In order to create certainty for the market, and to keep the number of cap changes as small as possible, an estimate of required import allowances could be made before the start of the CBAM, and the related cap adjustment could take place "*ex-ante*", i.e. before the CBAM actually starts. The timeframe for doing the *ex-ante* estimate could be five years, for example, like the current periods for free allocation, or it could be annually updated in order to adjust to the latest import data. However, any such method based on a forecast has a systematic drawback, which is the risk of ending up with an incorrect estimate. If it is too low (i.e. if imports are higher than anticipated), EU ETS market scarcity would be tightened, and the allowance price could be significantly higher than expected for an EU ETS without a CBAM. On the other hand, if the cap increase is too high, the EUA price would drop too low. However, this situation would be of less concern, provided the design of the Market Stability Reserve (MSR[124]) would be adjusted accordingly, so that the extra allowances

[124] Legal basis: Decision (EU) 2015/1814 of the European Parliament and of the Council of 6 October 2015 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and amending Directive 2003/87/EC.

would be absorbed by the MSR. With a strong MSR in place, the environmental integrity of the EU ETS can be maintained, as the EUA price would remain sufficiently stable to continue an effective incentive to reduce emissions. However, as currently both the EU ETS and the MSR design are under review, the addition of a CBAM as another variable could make it difficult to end up with a system that satisfies all needs. Hence, Option Cap3 seems undesirable.

  - Option Cap4 – "MSR-based approach". The current EU ETS legislation foresees that the surplus contained in the MSR above the previous year's auctioning amount would be cancelled from 2023 onwards. This provision could be dropped, so that the allowances kept in the MSR could be used to cover the imports under the CBAM, without further change to the EU ETS cap. This would not work in the distant future, as the allowances kept in the MSR would be exhausted after a few years, buying time to carry out a thorough assessment of the CBAM's operation and the MSR's future design parameters. Nevertheless, this option seems rather complicated and is not recommended.

- If a **tax** is used for fulfilling the CBAM obligation (Option Pay.3), no impact on the EU ETS would be expected, except for the "generic impact" described below.

- The same applies for **main design Option 4 (excise) and Option 5 (carbon added tax)**. The mechanism does not involve any EU ETS allowances and only the "generic impact" would be observed.

- **Generic impact** of a CBAM on the scarcity of allowances. For all design options of a CBAM, the balance between products produced domestically (under the EU ETS) and imported may be shifted as a consequence of a CBAM that reduces the risk of carbon leakage. In particular, the expectation would be that imports of goods with high "carbon content" take place less frequently. Consequently, even when considering an option without allowance surrender, the balance of supply and demand of allowances in the EU ETS may increase slightly as a result of some increasing production levels within the EU ETS substituting imported goods. If such an increase were to happen, the allowance price would increase compared to the non-CBAM case as a consequence of rising emissions in the EU ETS and the resulting higher allowance demand. However, it may well be that such impact remains theoretical or at least not measurable.

5.8.3 Other impacts on the EU ETS

The CBAM may have an impact on administrative processes of the EU ETS, such as in the area of monitoring, reporting and verification. On the one hand, it could mean for operators, verifiers and competent authorities that the administrative burden would decrease significantly because free allocation could be ended (not applicable to main Option 2), and the related MRV requirements under FAR and ALC Regulation would be ended[125]. On the other hand, however, for the purpose of defining reference values for embedded emissions and other parameters, it might mean that additional reporting requirements (at least as a one-off exercise) would have to be established. It will be interesting to find the right balance. Synergies between EU ETS and a CBAM could be exploited if the same authorities were involved, and if deadlines on the respective compliance cycle were coordinated (see Section 5.2.7). Furthermore, synergies between a CBAM and the development of ETS at the international level could take place, should international cooperation in the form of international expert working groups be established.

[125] Note that ending these MRV requirements would lead to a loss of transparency in the EU ETS, as the benchmarks would no longer be updated, and no new information on the efficiency of European installations would be gathered.

Impact on EU and Member State budgets: As the CBAM is currently envisaged to provide "EU own resources", the CBAM would collect a significant amount of money at EU level, while (if free allocation is ended), the budgets of the EU Member States would also benefit from a CBAM. However, the figures will strongly depend on the final design of the CBAM, in particular what definition of "embedded emissions" is chosen (see Section 5.2.3 and conclusions in Section 5.5) and which industry sectors / product groups will form the scope of the CBAM (see Chapter 4).

5.9 of compliance and enforcement costs

Compliance and enforcement costs refer to the costs that are incurred by businesses for complying with rules and obligations, and for authorities to administer the mechanism and ensure the rules are respected. This section assesses the costs of the different CBAM options following a standard cost model approach.

5.9.1 Structure

The assessment of compliance and enforcement costs considers the different design elements of setting up the various options of a CBAM. On the one hand, these can be largely similar across options, but on the other, these also vary depending on the choice of implementation. For all options, existing processes and their costs for businesses and authorities have been considered only to quantify new costs additional to the business as usual scenario.

This section assesses the following parameters to cover possible combinations of option design and implementation setup.

1. Whether the choice of instrument is an import tax, uses notional EU ETS allowances[126] (applicable to Options 1 -3, see payment options in Section 5.4.1), or an excise duty system (applicable to Option 4).
2. Whether the mechanism relies fully on default values or is one in which importers claim individual treatment based on actual emission values (see Section 5.2.6).

For each of these parameters, cost elements have been identified based on the necessary process. Cost elements can be based on information obligations that define the data economic operators need to be able to provide to authorities or on transaction costs related to the payment itself. These cost elements have been standardised to unit costs to reflect single elements that can be multiplied by the number of yearly occurrences. The single unit varies between the cost elements. Some occur on at installation level (e.g. monitoring costs), while costs per declaration or per economic operator are the single unit for other elements such as the surrender of the payment or allowances.

For the enforcement costs of authorities, the same method is followed to the extent that data is available. Wherever possible, similar sources of data to the costs for businesses have been used to ensure comparable estimates. However, in particular for the implementation as an excise, this data was not available in a similar way to the options using notional ETS allowances or an import tax. A comparative overview is nonetheless possible and presented in Section 5.9.7.

5.9.2 Data

In order to estimate the compliance costs for economic operators and determine the drivers behind enforcement costs for authorities, data from cost assessments of existing mechanisms is used. Cost elements are estimated on the basis of similar elements in instruments such as the EU ETS, national emissions trading systems, existing excises or import taxes, as well as the Clean

[126] For the purposes of simplification, the surrender of "actual" EU ETS allowances is not assessed separately in this section.

Development Mechanism (CDM)[127], which is an international instrument for emissions from international installations and projects. Therefore, **it is a central assumption of this assessment that CBAM cost elements are mainly comparable to the similar elements of existing mechanisms**. Important deviations from this assumption, notably in the case of emissions monitoring, will be mentioned and discussed below.

For cost elements of EU instruments and excises, data on national implementation in the Member States is the main source of information. In the assessment activities, the most recent, comprehensive data is used to reflect process simplifications from the digitalisation of customs and tax procedures in the EU. The estimations on the number of imports, businesses or installations are based on data from industry associations, reports prepared for the European Commission as well as EU and national tax and customs databases.

Some data sources are academic papers, others have been collected in public databases or form part of impact assessments and evaluations at the national level. Academic research, however, also provides important comparative assessments between economic policy instruments that help to understand the context and validate the results for one option in relation to others. As such, research articles find that compliance costs for customs and excise instruments are the lowest of all tax instruments (Eichfelder & Vaillancourt, 2014, Smulders et al., 2012). However, this relates to weight, volume or value-based instruments and does not consider the monitoring of emissions in third countries. Moreover, the literature provides evidence that important cost drivers for all types of instruments are the number of taxpayers, the frequency of reporting and the number of exemptions and differing rates (Barbone et al., 2012).

Overall, the estimations provided in this report are based on instruments that have been in place for several years, which has led to reductions of problems in efficiency. **A newly established CBAM as the first of its kind would likely result in higher costs initially**. Thus, the estimations made in the sections below are approximations. While the absolute costs of a CBAM could be higher, the assessment enables an evidence-based comparison of the options and their implementation.

5.9.3 Assumptions

For the estimation of the costs for businesses and authorities, the assessment is based on a set of assumptions. First, general assumptions underlying the assessment are as follows.

- Compliance costs are assumed to arise for importers located in the EU that would have to pay the CBAM obligation. This could be done either on the basis of a default value or by providing verified information about actual emissions, if voluntarily chosen by the importer. While the monitoring of these actual emissions would take place outside the EU, the responsibility – and thus the costs – of providing the information to authorities lies with the importers.
- For CBAM options which use default values, it is assumed that all importers report such monitored actual emissions. For the initial phase, this is realistic in the case that actual emission values are made mandatory by the legislator.

[127] https://cdm.unfccc.int/about/index.html.

- As already mentioned above, the CBAM is assumed to result in costs comparable to those of existing, similar mechanisms. However, the CBAM will target imports of products and their embedded emissions. Therefore, costs taken from existing mechanisms to monitor installations' emissions are generally doubled to create an estimation for the production of multiple products in one installation. This estimation is based on own expertise and reflects the additional burden for monitoring emissions related to the production process of the different products.
- The number of occurrences for installations, imports and economic operators are based on the steel, cement, aluminium, polymers, fertilisers and petrochemicals sectors. A narrower or broader scope would therefore reduce or increase the respective numbers. From these sectors, basic material imports are considered. The inclusion of basic material products would increase the number of cases and subsequently the costs, notably for the border mechanisms import tax and notional EU ETS allowances.
- For the assessment of the cost of individual treatment based on actual embedded emissions, the number of relevant global installations is estimated on the basis of the number of EU installations and the relation between EU production and imports[128]. The total number could in reality be lower due to importers deciding to import from fewer installations to increase the efficiency of MRV obligations.
- The number of import actions per year is estimated on the basis of imported quantities in relation to the average share of import modes for sea, road and rail[129]. Given the nature of basic materials, a large share of bulk shipments is assumed, which results in a low number of import events in relation to the weight of imports. The average capacities of bulk shipments for the modes of transport are based on information from logistics service providers.
- The number of importers is estimated on the basis of the number of Authorised Economic Operators[130]. The share of obliged importers is assumed to reflect the share of import value of the mentioned basic materials out of the value of all EU imports[131].
- Importers are assumed to have existing relations and exchange with customs authorities due to customs declarations, and also involving payments, because of existing obligations such as import sales tax. Therefore, basic data on quantity and origin is available, with the main information missing being the embedded emission from the production process.
- The creation of an excise duty would oblige domestic producers and businesses in the value chain. Therefore, the introduction of an excise is assumed to create comparable cost elements as existing excises (e.g. on tobacco or alcohol). In contrast to other existing excises on goods like alcohol or tobacco, it is assumed that real-time tracking through the Excise Movement Control System[132] is not necessary, because of the low excise value in relation to the weight of the product.

Expressed in numbers, these assumptions translate into a number of estimated cases for non-EU installations, importing operators and import actions. These numbers form the basis for the multiplication of standardised unit costs to estimate the total costs of the options.

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[128] Data sources: publicly available industry data from European Aluminium, Cefic, Petrochemistry.eu, Ecorys et al. 2019, and the US International Trade Administration.

[129] Eurostat, 2020: https://ec.europa.eu/eurostat/statistics-explained/index.php/International_trade_in_goods_by_mode_of_transport#Trade_by_mode_of_transport_in_value_and_quantity.

[130] https://ec.europa.eu/taxation_customs/general-information-customs/customs-security/authorised-economic-operator-aeo/authorised-economic-operator-aeo_en.

[131] Data sources: industry data, Eurostat, 2020: https://ec.europa.eu/eurostat/statistics-explained/index.php/International_trade_in_goods.

[132] https://ec.europa.eu/taxation_customs/business/excise-duties-alcohol-tobacco-energy/excise-movement-control-system_en.

Table 5-4: Number of estimated cases for third-country installations, importers and import transactions.

Number of third-country installations	510
Number of importers	1 000
Number of import transactions per year	239 000

Source: own estimations based on industry and statistical data[133]

For an excise option the number of cases expresses the number of businesses and installations producing, importing, processing and storing goods containing the basic materials covered by the CBAM. Because of the nature of basic materials as input in different value chains, a number ten times the number of EU installations in the steel, cement, aluminium and petrochemicals sectors plus the third-country installations is assumed for this. This is again based on expertise in the project team and the common use of the materials. The result is 10 000 cases for the excise system.

It should be noted that the numbers provided here and below, as well as the corresponding results, are estimates with potentially significant margins of errors.

5.9.4 Assessment of compliance costs for businesses

Following the general remarks and assumptions set out above, this section will assess and estimate the compliance costs for businesses that arise from the different options and their implementation.

When outlining the cost elements, it is important to note that they differ between the border instruments and the excise. The former comprises the implementation through the surrender of notional EU ETS allowances and the payment of an import tax.

On the one hand, design **Options 1 to 3** rely on an adjustment of the carbon price at the border using the payment options of an import tax or (notional) EU ETS allowances. For these border instruments, the cost elements are the following.

- First and most importantly, the quantification of the emissions value that forms the basis of the calculation of the carbon price for design options in which importers claim actual emissions. This includes:
    - monitoring the quantity of imported products;
    - tracking the place of origin;

[133] Data on industries: https://legacy.trade.gov/steel/countries/pdfs/imports-eu.pdf; Ecorys et al. 2017: http://publications.europa.eu/resource/cellar/07d18924-07ce-11e8-b8f5-01aa75ed71a1.0001.01/DOC_1; European Aluminium: https://www.european-aluminium.eu/activity-report-2019-2020/market-overview/; VCI 2020: https://www.vci.de/vci/downloads-vci/publikation/chemiewirtschaft-in-zahlen-print.pdf; CEFIC: https://cefic.org/app/uploads/2019/01/The-European-Chemical-Industry-Facts-And-Figures-2020.pdf.
Importers: Based on number of overall AEOs in the EU: https://ec.europa.eu/taxation_customs/dds2/eos/aeo_consultation.jsp?Lang=en; and the share of imports in each sector (in terms of value) of the overall value of imports: https://ec.europa.eu/eurostat/statistics-explained/index.php/International_trade_in_goods#:~:text=EU%2D27%20international%20trade%20in,exports%20(EUR%2073%20billion).
Import transactions: Imported quantities taken for each industry from the sources above; Modal split of imports: Eurostat, 2020: https://ec.europa.eu/eurostat/statistics-explained/index.php/International_trade_in_goods_by_mode_of_transport#Trade_by_mode_of_transport_in_value_and_quantity; Cargo industry data, mainly: https://www.dsv.com/en/our-solutions/modes-of-transport/sea-freight/shipping-container-dimensions/dry-container; https://www.marineinsight.com/types-of-ships/different-types-of-bulk-carriers/; https://www.csx.com/index.cfm/customers/resources/equipment/railroad-equipment/.

    - monitoring the embedded carbon emissions of products stemming from the production process;
    - verification of the monitored emissions.
- Cost related to the documentation of the process, including the submission of information to the CBAM facility (see Section 5.3).
- Costs related to making the payment.
- Costs related to the preparation for controls by the authorities.

On the other hand, **Option 4** proposes the implementation of a CBAM with an excise duty system. For this option, the cost elements differ and comprise the following steps.

- Again, the first important cost element is the quantification of the emissions value and the related excise amount. As the excise option fully relies on default values, this involves:
    - monitoring the weight of basic materials, including imported and domestically produced goods;
    - accounting for the movement of the basic material along the value chain including manufacturing businesses.
- Costs related to the administration of the processes, such as trading licences or requests for specific uses of the material.
- Costs related to the documentation of materials and goods.
- Costs related to the payment.
- Costs related to the verification of information by the authorities.

Based on these cost elements, the options for implementation are assessed in the following sections.

Import tax

For the first set of cost elements related to the quantification of emissions, based on the outlined assumptions, monitoring the quantity of imported products and their origin does not cause substantial added burden to businesses. In a CBAM option that purely relies on default values, monitoring of the emissions from the production process is not necessary and therefore also does not create substantial costs. However, in an option that has importers claim the actual emissions from the production process, the monitoring creates substantial costs for the business. Based on estimates of the transaction costs of the CDM, monitoring emissions of an installation are quantified at EUR 10 200 per year (Krey, 2004). Assuming the doubled costs for monitoring production processes instead of entire installations, this results in EUR 20 400 per year and non-EU installation.

The verification of claimed emissions adds further costs if there is a deviation from default values. A report on the national implementation of the EU ETS in the United Kingdom estimates yearly verification costs for an installation at EUR 4 000 (Talbot, 2016). Estimations for the CDM, however, indicate a span for verification costs between EUR 4 000 and EUR 15 300 per installation and verification cycle (Krey, 2004). It should be noted that these figures relate to the monitoring and verification at the installation level. As pointed out above, the differentiation between products from one plant would require more granular tracking of emissions and is expected to increase the costs for both monitoring and verification substantially. Therefore, the cost estimate presented here is a conservative amount.

As a second cost element, the documentation and reporting of the quantities and emissions is assessed on the basis of the reporting costs estimated for UK businesses under the EU ETS, with an estimation of EUR 900 per year and per business (Talbot, 2016). As a higher frequency of documentation is assumed for an import tax, this number is estimated to be up to six times higher. This is based on less information needed to be documented, but more often during a year.

The payment of the CBAM in the form of an import tax is considered to be a negligible additional burden because an existing tax and customs payments relationship between the importer and the authorities is assumed.

Finally, the costs of preparation for controls are included, for options of claimable actual emissions, in the costs for MRV described above. For options relying on default values, checks and audits do not involve substantially more information than existing mechanisms and therefore the additional costs are negligible.

Table 5-5 summarises the above. In total, the sum of yearly standardised cost estimations amounts to EUR 5 400 per importer for options based entirely on default values.

In contrast, options which involve claiming actual emissions result in total yearly costs of between EUR 30 800 and EUR 43 800 when quantifying actual emission values. Data on yearly MRV costs of the EU ETS implementation in Germany (on installation level, not product-specific) estimates EUR 23 700 per installation[134]. This validates the estimations for cost elements and indicates an amount closer to the higher end of the range. In addition, the low costs for the default value option is in line with academic findings on the low level of compliance costs with border tax measures, as outlined above.

Table 5-5: Annual compliance costs estimates (in EUR 1 000) for a CBAM implemented as an import tax.

[134] Destatis OnDEA database, calculation for 1900 ETS participants:

https://www.ondea.de/SiteGlobals/Functions/Datenbank/Vorgaben/Einzelansicht/Vorgabe_Einzelansicht.html?cms_idVorgabe=12746.

Determination of emission intensity / Cost elements	Default values only	Possibility to present actual emissions
Monitoring of basic material quantities	negligible extra burden	negligible extra burden
Tracking of origin of products	negligible extra burden	negligible extra burden
Monitoring of embedded emissions from production process	negligible extra burden	20.4 (for plant emissions)
Verification of monitored emissions	negligible extra burden	4 - 18 (for plant emissions)
Submission of documentation of imports	5.4	5.4
Tax return and tax payment	negligible extra burden	negligible extra burden
Inspection and audit costs to be prepared for verification by authorities	negligible extra burden	1-2
Total (standardised costs[135])	**5.4**	**30.8 – 43.8**

Sources: Krey 2004, Talbot 2016, Destatis OnDEA database, own expertise.

The result for overall yearly costs for EU businesses is calculated on the basis of the estimates and the number of cases. **For an import tax relying entirely on default values, the compliance costs amount to EUR 5.4 million per year**.

For an import tax using actual emission values, it is assumed that all importers are claiming actual emissions. **The total cost for such a CBAM amount to EUR 18.84 million to EUR 26.98 million**. If only 50% of importers submit actual emission values while the other 50% uses default values, the total compliance costs drop to between EUR 11.8 million and EUR 15.7 million.

Notional ETS

As the cost assessment for implementation using notional EU ETS allowances follows very similar requirements and thus also cost elements, the considerations largely overlap with the one made above.

Therefore, the estimated standardised costs for the quantification of emissions and, as a result, allowances to be surrendered, documentation and control are assumed to be similar to costs

[135] Unit differs between third-country installations for MRV and inspection costs, and importers for documentation.

arising from an implementation based on an import tax, to ensure equal levels of accuracy and control. However, regarding the payment, an additional mechanism – the buying and surrendering of notional ETS allowances – creates new costs for businesses. Additionally, the costs of having a registry account contributes between EUR 0 and 800[136]. Thus, based on this and assessments of national EU ETS implementation these costs are quantified at between EUR 40 and EUR 1 500 per year and participant[137].

Table 5-6 summarises the costs for the notional ETS design. Basing the CBAM entirely on default emission values results in yearly estimated costs of EUR 5 440 to EUR 6 900. If the CBAM allows the claiming of actual emission values, the estimated costs range from EUR 30 840 to EUR 45 300 per year.

Table 5-6: Compliance costs estimates (in EUR 1 000) for a CBAM implemented through notional EU ETS allowances.

Cost elements \ Determination of emission intensity	Default values only	Possibility to present actual emissions
Monitoring of basic material quantities	negligible extra burden	negligible extra burden
Tracking of origin of products	negligible extra burden	negligible extra burden
Monitoring of embedded emissions from production process	negligible extra burden	20.4 (for plant emissions)
Verification of monitored emissions	negligible extra burden	4-18 (for plant emissions)
Submission of documentation on imports	5.4	5.4
Purchase and surrender of notional allowances	0.04 – 1.5	0.04 – 1.5
Inspection and audit costs to be prepared for verification by authorities	negligible extra burden	1 -2
Total (standardised costs[138])	**5.44 – 6.9**	**30.84 – 45.3**

Sources: Krey 2004, Talbot 2016, Destatis OnDEA database, own expertise.

Again, the result for overall yearly costs for EU businesses is calculated on the basis of the estimates and the number of cases**. For CBAM implemented as the surrender of notional EU**

[136] Umweltbundesamt, 2015. Evaluation of the EU ETS Directive.

[137] Destatis OnDEA database: https://www.ondea.de/DE/Home/home_node.html; Talbot, 2016.

[138] Unit differs between third-country installations for MRV and inspection costs, and importers for documentation and surrender of allowances.

ETS allowances relying entirely on default values, the compliance costs amount to EUR 3.96 million to EUR 5.03 million per year.

For an implementation as notional ETS allowances using actual emission values, it is assumed that all importers are claiming actual emissions**. The total cost for such a CBAM amount to EUR 18.88 million to EUR 28.48 million.** If only 50% of importers submit actual emission values while the other 50%, the total compliance costs drop to between EUR 11.9 million and EUR 17.2 million.

Excise duty

The cost elements for the excise duty are composed differently than the previous two options, which both make the adjustment at the point of import. In addition to the difference in instrument that also includes transactions within the borders of the EU, the proposed excise option considers as design elements (1) the default values for the quantification of the excise, and (2) the downstream value chain of basic materials.

As described above, the estimation of compliance costs for an excise assumes cost elements similar to existing excises. Detailed data on the compliance costs for excise obligations is available for German excise charges on tobacco, different types of alcohol or coffee. The cost elements below are taken from the Destatis' OnDEA database and standardised using case numbers available on the platform[139]. Table 5-7 below illustrates the estimated cost for an excise system.

First, the costs for monitoring and accounting of the product quantities for the calculation of the excise amounts to EUR 690 to EUR 1 990 per business (including those that further process the basic materials) and per year. Second, yearly costs for the administration of the process, including all the necessary licences to participate in a duty suspension regime, and permissions for differing uses add up to between EUR 230 and EUR 800 per business. Third, the documentation of transactions in excised goods, including the issuing of documents for products sold create annual compliance costs of EUR 1 290 to 1 500 per business. The payment of the excise and filing of tax returns is included in this amount. Lastly, the control and verification results in costs of EUR 100 to EUR 220 per business and year.

In total the standardised compliance costs of the excise option are then estimated to be between EUR 2 310 and EUR 4 510 per participating business.

Table 5-7: Compliance costs estimates (in EUR 1 000) for a CBAM implemented as an excise duty.

[139] Destatis OnDEA database: https://www.ondea.de/DE/Home/home_node.html.

Value chain coverage	Basic materials plus further value chain
Determination of emission intensity / Cost elements	Default values only
Monitoring and accounting of product quantities	0.69 - 1.99
Administration and licences	0.23 - 0.80
Documentation, including payments and filing of returns	1.29 - 1.50
Inspection and audit costs for verification by authorities	0.1 - 0.22
Total (standardised costs[140])	**2.31 - 4.51**

Sources: OnDEA database, own expertise.

Given the potentially higher number of businesses obliged by an excise, the relatively small unit costs for this option amount to relatively high total compliance costs. Assuming that one third of businesses does not make use of the duty suspension system and instead pays the obligation directly**, the estimated yearly total is between EUR 14.7 million and EUR 28.7 million.** If fewer businesses participate because of advantages of little pass-on of the excise or product substitution, the resulting costs would be lower.

5.9.5 Assessment of the impacts on SMEs

The assumptions and data available do not allow for a quantitative assessment of impacts of a CBAM specifically on small- and medium-sized enterprises (SMEs). However, the evidence body in the literature is well developed, both for the difference between large and smaller companies in the administrative burden of tax or customs measures, and for different cost structures for MRV of carbon emissions.

Research and reports on the burden of taxation largely align in their findings that small businesses face higher relative compliance costs for the main types of tax instruments. Eichfelder and Vaillancourt (2014) present such results linked to the higher costs for collecting the relevant information to report. More specifically in the case of valued added tax (VAT), Barbone et al. (2012) present a similar finding in the context of a review of research papers. This finding is also confirmed by a study conducted by KPMG and GfK on behalf of the European Commission (KPMG et al., 2018). Data collection for tax reporting is identified as the main cost driver. Total costs are found to be relatively higher for smaller companies. However, the core focus of all these studies relates to VAT and Corporate Income Tax (CIT). Customs and excise duties are less systematically assessed. In the EU study, they are found to be one of the most burdensome taxation types beyond VAT or CIT according to the high-level analysis (KPMG et al. 2018). A South African study,

[140] Unit: per authorised participant in the excise system.

Smulders et al. (2012), however, finds substantially lower compliance costs for customs and excises than for VAT or CIT. Recording of information is also found to be a main factor in this study, as well as familiarisation with the tax instrument.

The general literature on the compliance costs with carbon quantification instruments point in a similar direction. Academic work finds substantially higher administrative costs per tonne of CO2e for small emitters in emission quantification systems like the EU ETS (c.f. Coria & Jaraite, 2019) or the Clean Development Mechanism (c.f. Krey, 2004). The national compliance costs study of EU ETS implementation in the UK confirms these results (Talbot, 2016). Small emitters (<25 000 tonnes per year) in the EU ETS face compliance costs more than eight times higher than emitters of 50 000-500 000 tonnes.

Overall, this indicates that a CBAM would result in relatively higher compliance costs for SMEs compared to large enterprises. As mentioned above, the exact degree of difference between the two groups could not be quantified based on the currently available data.

Information on the structure of the sectors under consideration is not comprehensively available for the entire EU because it is classified as confidential in many Member States. Calculations based on Eurostat data[141] for the sectors' NACE codes (three digits) result in a total number of 31 000 SMEs in the sectors considered for a CBAM in this study. However, this number needs to be considered in context. First, the production value of SMEs in the sectors of the dataset – based on the available data – amounts to 19% of the overall production value. Second, the data includes wider sector definitions than the proposed product scope of this study. For instance, ceramics are included in the cement sector. This can be expected to change the structure significantly, as some subsectors (like ceramics) have a much higher share of SMEs than the raw materials considered[142]. The fact that a CBAM applies to imports of a few basic materials and basic material products results in large businesses being those mainly impacted. **Therefore, the practical impact of import-related measures would have little practical impact on SMEs,** even though this impact would be relatively higher than for large businesses if the amounts imported are compared.

An option that includes products further along the value chain, or also EU internal transactions like the proposed excise option, would result in a substantially larger share of SMEs targeted by the CBAM measures and therefore also in higher compliance costs for SMEs overall. A study on the compliance costs of the REACH Regulation[143] which applies to EU manufacturers and importers highlights the greater burden for SMEs, compared to large companies (CSES et al., 2015)[144]. The quantification of this effect for the CBAM is however not possible at this point as sufficient data is not available.

5.9.6 Assessment of enforcement costs for the administration

The assessment of enforcement costs focuses on identifying the drivers of costs for authorities in the enforcement of the CBAM options.

Essentially, the authorities face comparable cost elements as the businesses, with the difference that costs arise from assessing information and checking the reports from economic operators. The literature describes the same cost drivers for administration and enforcement costs as for compliance for taxation measures (Barbone et al., 2012). Most importantly, this is the complexity

[141] https://ec.europa.eu/eurostat/databrowser/view/SBS_SC_IND_R2__custom_553424/default/table?lang=en.

[142] EU-MERCI. Analysis of the industrial sectors in the European Union. http://www.eumerci-portal.eu/documents/20182/38527/0+-+EU.pd.f

[143] Regulation on the registration, evaluation, authorisation and restriction of chemicals. EC Regulation No 1907/2006.

[144] See also SWD(2018) 58 final.

of the system, including the number of different rates, exemptions or documents required. Therefore, **the options that have been found as more costly for businesses above, in general also create higher costs for the authorities**.

As the authorities already assess customs declarations for imported goods in the volume and scope of this study, it is clear that existing infrastructure and processes are in place. This assessment of enforcement costs will again provide estimations on the additional costs compared to the business as usual scenario. This applies mostly to data processing and exchange, but also to controls and payments. The following sections will provide details on the specific options.

The sections provide estimations for the administration assessed and compliance costs. In line with the compliance cost assessment, the estimations are based on studies published by the European Commission[145] as well as impact assessments at EU and national levels[146]. In cases where the enforcement effort was indicated in a time duration, the average hourly wage costs of the EU[147] were used to estimate the resulting costs.

IT infrastructure

An overarching cost element is to have the necessary IT technology in place. Data collected at the time of import by customs authorities needs to be shared with the authorities in charge of assessing declared actual emissions (if applicable) and connect the imported products to allowances either already surrendered at that point or to be surrendered (if applicable)[148]. In any case, data on the imported quantities and related carbon prices has to be shared with a central European system to collect the CBAM revenue as an EU own resource. The same also applies to the option of implementation as an excise, as this would also require an interface between Member States and the Commission, including the customs organisations.

According to discussions with Commission experts on tax administration, this can represent a major share of the costs. The implementation of the EU VAT rules for e-commerce support this indication with estimated costs of EUR 2.2 million per Member State for the introduction of a one-stop shop system (Deloitte, 2016). Across the options assessed below, the need for additional IT systems varies slightly depending on their complexity and the need for collaboration, but additional infrastructure would in all cases be necessary to process the data and share it between customs and CBAM authorities.

Similar to some existing requirements on imported goods such as ozone-depleting substances or F-gases, the CBAM could also be part of the recently-launched Single Window Environment for Customs[149] that facilitates automatic assessment and sharing of import-related data. Including the CBAM obligation in this environment would reduce costs for IT systems and also for the processing of the documents. However, setting this up would require time and result in some limitations in the implementation. For example, a centralised assessment of monitoring data would be necessary. A decentralised approach involving Member States' existing structures would not be supported by this environment, as discussions with Commission experts have shown.

[145] Amec Foster Wheeler Environment, 2016. Evaluation of EU ETS Monitoring, Reporting and Verification Administration Costs. http://publications.europa.eu/resource/cellar/f6a49ec5-c35c-11e6-a6db-01aa75ed71a1.0001.01/DOC_1.

[146] Impact assessment of EU customs and tax instruments, the implementation of EU legislation in Germany, and of taxation initiatives in the UK.

[147] https://ec.europa.eu/eurostat/statistics-explained/index.php/Wages_and_labour_costs

[148] See subsequent sections for the costs of the different set-ups and section 5.4for detailed explanations of the process.

[149] https://ec.europa.eu/taxation_customs/general-information-customs/electronic-customs/eu-single-window-environment-for-customs_en.

Depending on the inclusion in the Single Window or not, the costs will differ substantially. Compared to the estimated EUR 2.2 million per year and per Member State for a decentralised IT system, the new Single Window Environment could be adapted to include the CBAM in its centralised data sharing. Individual Member States would face lower costs, while the Commission bears a large part of the costs for maintenance and support. The impact assessment for the Single Window Environment is EUR 9.2 million per year for the Commission during the gradual implementation (first seven years) and between EUR 350 000 and EUR 680 000 per year and Member State[150]. As the central system will be in place by the time the CBAM enters into force, the yearly costs for the IT infrastructure, in particular for the Commission, are expected to be lower than the figures given here.

Import tax

For CBAM options using an import tax, efforts are necessary to process documents, administer payments and controlling the correct declaration of goods. In the case of reported actual emissions, these reports and validations would also need to be assessed. Except for the last cost element, customs authorities already perform these tasks. A CBAM that fully relies on default values would be based for most of its administrative needs on existing processes. The carbon price applicable to an import transaction would be based on the product category and the weight, both of which data points are already collected. This would be the only additional requirement, which adds a small marginal amount of cost. The collection of the import tax directly at the time of import (under Cycle.1, see Sections 5.2.7 and 5.5) would already be included in this figure. As a second point, additional controls by customs authorities would be necessary to ensure the right product categories are declared. The carbon price increases the risk of fraud by declaring products that are not covered by CBAM. Therefore, the controls at entry points to the EU on a sample of imports are necessary and result in additional enforcement costs. These costs are estimated on the basis of the standardised estimations of costs for additional controls to enforce the import elements of the VAT obligations of e-commerce[151].

In comparison, an import tax with the option or even expectation of presenting actual emission values is more complex and creates higher enforcement costs. The processing of customs declarations would require more time, as the existence of an emissions report supporting the declared carbon content would need to be checked. Considering the proposed compliance cycle Cycle.3 (see Section 5.2 above), the CBAM obligation would need to be paid on the basis of the emissions declared at the time of import. Together with the necessary controls (see above), this would complete the task of the customs authority. However, the declared actual emissions would have to be assessed by a competent climate authority. The monitoring report provided by the importer and its verification would need to be assessed. As the reporting has to be performed at product level and in non-EU countries, the costs are again assumed to be twice the amount of assessing EU ETS reports. Based on cost estimations for the EU ETS[152], this results in costs of EUR 6 750 per installation from which products are imported. Using the proposed Cycle.3 option, a reconciliation of payments needs to be made at the end of a compliance cycle. The administration of these additional payments by the importers or of refunds where the actual emissions were lower creates costs that do not arise when using default values. Using the administration of EU ETS

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[150] SWD(2020) 239 final, https://ec.europa.eu/taxation_customs/sites/taxation/files/201028_single_window_impact_summary.pdf; and SWD(2020) 238 final, https://ec.europa.eu/taxation_customs/sites/taxation/files/201028_single_window_impact.pdf.

[151] German Parliament, 2020a. Entwurf eines Jahressteuergesetzes 2020. http://dipbt.bundestag.de/dip21/btd/19/228/1922850.pdf.
See also: https://ec.europa.eu/taxation_customs/business/vat/modernising-vat-cross-border-ecommerce_en.

[152] Amec Foster Wheeler Environment, 2016. Evaluation of EU ETS Monitoring, Reporting and Verification Administration Costs. http://publications.europa.eu/resource/cellar/f6a49ec5-c35c-11e6-a6db-01aa75ed71a1.0001.01/DOC_1.

accounts as a proxy[153], this element is estimated at EUR 400 per importer per year. In addition, it is assumed that a small number of site inspections at production sites would also be carried out to verify compliance at the level of production process. As this is assumed to target only a sample every year, the costs are estimated at EUR 351 per installation per year[154].

Table 5-8 summarises the ongoing administration and enforcement costs for CBAM options based on an import tax. To these need to be added the costs for setting up and maintaining the IT infrastructure.

Table 5-8: Yearly administration and enforcement costs for an import tax-based CBAM in EUR.

Costs / Cost element	Unit costs[155]		Overall costs	
	default factors	**actual emissions**	**default factors**	**actual emissions**
Processing of customs declarations	3	6	690 000	1 380 000
Assessment of monitored actual emissions	0	6 750	0	3 442 500
Administration of accounts/payments	included above	400	0	400 000
Customs controls	75	75	8 625 000	8 625 000
Site inspections	0	351	0	179 010
Total (yearly)	**78**	**7 582**	**9 31 ,000**	**14 026 510**

Sources: Amec Foster Wheeler Environment, 2016; German Parliament, 2020a; own expertise.

Notional ETS

The administration and enforcement costs for the implementation of the CBAM using notional ETS allowances is structured very similarly to the import tax option described above. The main difference is the greater involvement of an authority responsible for issuing and administering the surrender of the allowances. As the CBAM is designed as an EU own resource, the following considerations are based on the assumption that **a central authority would be tasked with this**. In contrast, a setup similar to the EU ETS with national competent authorities is also conceivable. This is expected to result in substantially higher costs, because of the stronger need for collaboration and coordination of the assessment of monitoring reports.

As the CBAM based on notional ETS would also be charged at the point of import, customs authorities need to process the information about the imported product. The need to surrender

[153] See below and Amec Foster Wheeler Environment, 2016.

[154] Based on costs for EU ETS inspections (Amec Foster Wheeler Environment, 2016), tripled to reflect the additional complexity of non-EU installations and emission monitoring at product level.

[155] Units. Processing of documents: per import transaction; assessment of monitored emissions: per third-country installation; administration of accounts: per importer; customs controls: per import transaction; site inspections: per third-country installation.

allowances would have to be included in the customs declaration and either allowances directly surrendered or added up for a final balance at the end of one year. While customs will always have an important role, the option of requiring a surrender or proof of surrender of the allowances at the time of import will have a significantly higher impact on customs costs. If customs authorities only collect this information on behalf of a CBAM authority that in turn performs the yearly balance, reconciliation and ensures submission, the costs for customs authorities are lower, as those costs would be shifted to the CBAM authority. The costs would arise in both cases, either for customs authorities or for the CBAM authority, and are for this assessment assumed to be similar to each other.

In the scenario where default values are used to calculate the allowances to be surrendered, the administration of the importers' accounts would be the main cost difference to the costs of an import tax based on default values. The costs here are estimated on the basis of the assessment of such costs for the national implementation of the ETS in Germany[156]. Given the greater complexity that results from international accounts that also need to be administered, the reported costs are again doubled. As a result, EUR 400 per year and per importer account are assumed for the administration of accounts and payments such as the supervision of the surrender of allowances. Additional customs checks are estimated to be similar to the costs for the import tax.

As mentioned repeatedly above for both compliance costs for industry and for enforcement costs of the import tax, the option of submitting actual emissions as the basis for the calculation of the CBAM creates higher costs compared to the use of default values. The need for emission monitoring reports to support the claimed actual emissions on which the self-declared CBAM obligation is calculated creates further complexity for the processing of customs declaration by the customs authorities. Similar to the import tax, the monitoring reports and verifications need to be assessed by a relevant authority, for example the central EU CBAM authority. The costs for this are – just as for the import tax above – estimated at EUR 6 750 per report. This cost element would increase significantly in the case of decentralised assessment of the MRV documents. In this case, authorities in multiple Member States would have to assess the documents of an installation unless exchange and acceptance of the decisions in other Member States is the case. In addition, the same costs for site visits as for the import tax are assumed, adding on average EUR 351 per installation.

Table 5-9 summarises the administration and enforcement costs for CBAM options based on notional ETS allowances. To these, the costs for setting up and maintaining the IT infrastructure need to be added.

Table 5-9: Yearly administration and enforcement costs for a notional ETS allowances-based CBAM in EUR.

Costs / **Cost element**	**Unit costs[157]**		**Overall costs**	
	default factors	**actual emissions**	**default factors**	**actual emissions**

[156] German Parliament, 2020b: Entwurf eines Gesetzes zur Anpassung der Rechtsgrundlagen für die Fortentwicklung des Europäischen Emissionshandels. https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Glaeserne_Gesetze/19._Lp/tehg_novelle/entwurf/tehg-novelle_180801_rege_bf.pdf.

[157] Units. Processing of documents: per import transaction; assessment of monitored emissions: per third-country installation; administration of accounts: per importer; customs controls: per import transaction; site inspections: per third-country installation.

Processing of customs declarations	6	9	1 380 000	2 070 000
Assessment of monitoring and reporting action	0	6 750	0	3 442 500
Administration of accounts/payments	400	800	400 000	800 000
Customs controls	75	75	8 500 000	8 500 000
Site inspections	0	351	0	179010
Total (yearly)	**481**	**7 985**	**10 280 000**	**14 991 510**

Sources: Amec Foster Wheeler Environment, 2016; German Parliament, 2020b; own expertise.

Excise duty

As in the previous sections on practical implementation (Sections 5.4 and 5.6) and the assessment of compliance costs, the option of implementing a CBAM with an excise duty (Option 4) requires a different setup of administration and enforcement. Based on expertise within the team and discussions with tax administration experts in the European Commission, the implementation of an excise duty on carbon-intensive material would be similar to existing excise duties. However, the discussions reveal that there are different configurations of excise duties or consumption charges that result in substantially differing enforcement requirements and costs for authorities.

Data sources for existing excises are scarce and not comprehensive in their assessment of different cost elements. The central element influencing the costs for enforcement of an excise or consumption charge is the requirement for movement control within a duty suspension arrangement and obtaining data from the producers and traders participating in this system. This is the case for excises on highly taxed products like tobacco. The high costs – not only for authorities but also for economic operators – are mentioned by the experts. As the excise system to implement a CBAM is assumed not to require such real-time tracking, the costs of enforcement can be limited in this respect.

Still, the excise requires processing data reported by businesses, maintaining the data infrastructure, and monitoring compliance through checks[158]. Important factors influencing the administration and enforcement costs are the complexity of products and the number of producers obliged to pay the excise. A higher number of producers increases costs for the authorities[159]. As discussed in the assessment of compliance costs for businesses, the number of producers will be high compared to common excises like on tobacco, because of the nature of the covered products, which are basic materials for many value chains.

Given the nature of the products and the similarity in setup, consumption charges for plastics provide a good reference point for the administration and enforcement of an excise duty on carbon-intensive basic materials. Currently, plastic levies are in preparation in Italy, Spain and the

[158] Ramboll et al. 2014: Study on the measuring and reducing of administrative costs for economic operators and tax authorities and obtaining in parallel a higher level of compliance and security in imposing excise duties on tobacco products. https://op.europa.eu/en/publication-detail/-/publication/a5d22256-3d16-4c7f-bb9e-3209447e517e/language-en.

[159] ECOTEC et al., 2001: Economic and Environmental Implications of the Use of Environmental Taxes and Charges in the European Union and its Member States.

United Kingdom. In the cases of Italy and Spain, impact assessments for the charge are still to be performed. The case of the UK provides an estimation of the overall ongoing costs. The impact assessment performed by the UK government foresees EUR 12.9 million per year for ongoing costs[160]. This includes implementing continuous changes in the collection systems, compliance monitoring and support to customers. An EU CBAM system could thus be expected to result in higher yearly costs than this. With the available evidence base, a more precise quantification is difficult to achieve.

5.9.7 Summary of the results of the costs assessment

As mentioned at the beginning of the cost assessment, the estimations made in the previous sections are approximations. While the absolute costs of a CBAM could be higher, the assessment enables an evidence-based comparison of the options and their implementations. The Options 1 (a and b), 2 and 3, presented and discussed in Chapter 3, could be implemented by obliging importers to either pay an import tax or to surrender notional EU ETS allowances. It should however be noted that the assessed options differ in key underlying features such as the value chain covered, which impacts the direct comparability of the options.

Option 1a would be an option resulting in comparatively low costs as it relies fully on default values. Under the assumptions applied in this compliance cost assessment, the total yearly costs amount to EUR 3.95 million for an import tax or between EUR 3.96 million and EUR 5.03 million for notional EU ETS allowances.

Option 1b would result in higher costs. This is because the option to claim the CBAM obligation based on actual emission values creates monitoring, verification and reporting costs for businesses in the EU. The estimated total yearly costs for this option amount to between EUR 9.8 million and EUR 13.2 million for an import tax or between EUR 9.8 million and EUR 14.3 million for notional EU ETS allowances.

Option 2 would result in similar costs, depending on the use of default values or the possibility to claim actual embedded emissions. The same applies to **Option 3**. However, the further depth of the value chain adds considerably more installations, importers, and import transactions. This increases the compliance costs compared to similar designs only targeting basic materials (and basic material products). **Option 4**, which takes the approach of introducing an excise, is estimated to result in relatively low unit costs but higher total costs because of the larger number of businesses obliged. The total for this option is estimated at between EUR 14.7 million and EUR 28.7 million.

Table 5-10: Estimated total compliance costs for businesses in EUR for Options 1a, 1b and 4.

Option number[161]	Import tax	Notional EU ETS	Excise
1a	5.4 million	5.44 million – 6.9 million	n/a
1b (assuming 100% use of actual emission	18.84 million – 26.98 million	18.88 million – 28.48 million	n/a

[160] Converted from GBP, https://www.gov.uk/government/publications/introduction-of-plastic-packaging-tax/plastic-packaging-tax.

[161] Options: Options 1a and 1b: CBAM on imports of carbon-intensive materials with full auctioning (1a: CBAM on imports at a reference level; 1b: CBAM on imports at level of actual emissions); Option 4: Excise including CBAM on carbon intensive materials including as part of products and continued free allocation.

values)			
4	n/a	n/a	23.1 million – 45.1 million

Considering the volumes of imports of all sectors considered in this study, the **compliance cost per tonne of import (Options 1a or 1b) or per tonne covered by the excise duty system (Option 4) would be very low** for import mechanisms using default values or an excise-based system. For an import mechanism using actual emission values, the costs per tonne would be slightly higher but still at a very low level of between 10 and 38 euro cents per tonne. Table 5-11 summarises these results.

Table 5-11: Compliance cost of CBAM options 1a, 1b and 4 per tonne of import in EUR.

Option number	**Import tax in EUR**	**Notional EU ETS in EUR**	**Excise in EUR**
	per tonne imported	**per tonne imported**	**per tonne covered by the excise system**[162]
1a	0.071	0.071 – 0.090	n/a
1b (assuming 100% use of actual emission values)	0.110 – 0.353	0.111 – 0.373	n/a
4	n/a	n/a	0.043 – 0.085

Sources: previous calculations, industry data[163], Eurostat[164]

Overall, it becomes clear that using default values for the quantification of embedded emissions results in significantly lower compliance costs than basing the calculations (partly) on actual, monitored and verified emissions. In comparison between the option of an import tax and a system of surrendering notional EU ETS allowances, the import charge creates marginally lower compliance costs. This is because of the easier integration in existing obligations. Other practical considerations of these options and their effect on the EU ETS are discussed in the previous sections of Chapter 5.

Enforcement costs for authorities are driven by similar factors as are compliance costs for businesses. The greater the complexity of the system the higher the costs of enforcement. For this reason, a CBAM using only default values (**Option 1a**) creates lower costs than options using more accurate emissions as reported by importers based on the monitoring in the production sites (**Option 1b**). For all options, compliance checks by customs make up a major share of the costs. In addition, the setup of an IT system to collect and exchange data between the authorities responsible adds another important share of the costs. These depend on the implementation in a

[162] Including both EU production and imports of the covered sectors.

[163] See data sources for Table 5-4.

[164] https://ec.europa.eu/eurostat/statistics-explained/index.php/International_trade_in_goods; https://ec.europa.eu/eurostat/statistics-explained/index.php/International_trade_in_goods_by_mode_of_transport#Trade_by_mode_of_transport_in_value_and_quantity.

centralised (with the option of inclusion in the Single Window Environment for Customs), or in a decentralised way. The latter is expected to create substantially higher costs than the former.

The options of an import tax or notional ETS allowances share many cost elements and have overall comparable costs. The main difference is the administration of payments. For an import tax, this would be collected by customs authorities together with existing import obligations. A system based on notional allowances would in all cases require an authority to sell such allowances and monitor their surrender.

In the case of actual emission values to be used for the calculation of the CBAM obligation, the assessment of the declared emissions adds another important cost element. Depending on the selection of a compliance cycle, the distribution of the costs between authorities differs. As the preferred implementation options for this suggest a reconciliation over a longer period (e.g. one year), the costs would be incurred in the CBAM authority rather than in customs authorities.

The implementation in coexistence with free allowance allocation under the EU ETS (**Option 2**) would result in similar costs for authorities as for Options 1a or 1b, depending on the choice between default values or actual emission values. For all these cases, the expansion of the scope to products of downstream processes or providing rebates to exports (**Option 3**) would increase the number of importers (or also exporters) and therefore result in substantially higher costs. The importers of products of downstream processes but also exporters of basic materials from the EU are for the most part different businesses than those importing the basic materials and basic material products under the narrower CBAM. The broader scope would increase the number of cases and in consequence the enforcement costs.

As before, an excise duty (**Option 4**) differs from the border instruments mentioned in the previous paragraphs. Because less data is available, the costs are more difficult to quantify. Based on recent cost estimates for a consumption charge on plastic in the UK, the overall enforcement costs for an excise are expected to be high, even without real-time movement control. This is because of the relatively high number of businesses importing or producing goods containing the basic materials and basic material products in the scope suggested in this study.

Table 5-12 summarises the estimations for enforcement costs for the different options.

Table 5-12: Estimated total enforcement costs for authorities in EUR for Options 1a, 1b and 4.

Option number	Import tax	Notional EU ETS	Excise
1a	9.3 million	10.3 million	n/a
1b (assuming 100% use of actual emission values)	14 million	15 million	n/a
4	n/a	n/a	>12.9 million

6. Electricity CBAMs and Alternatives

The conceptual analysis of options to implement a CBAM for electricity has been coordinated with analyses undertaken for DG Energy on this topic and hence some of the text is also aligned. The specific focus of this report is on the international experience and the evaluation against criteria defined for this study.

Box 3: Key messages on electricity CBAMs and alternatives

A key element of electricity CBAM designs is the calculation of the effective tax rate and its ability to differentiate the carbon content of imported electricity. The four options discussed are as follows.

- **Transaction-based approaches:** Transaction-based approaches set the carbon border adjustment on the emission intensity of individual transactions.
- **Marginal emissions-based approaches** set the carbon border adjustment on the marginal emission intensity of the exporting system.
- **Average-emissions based approaches** set the carbon border adjustment on the average emission intensity of the exporting system.
- **Joint Renewable Auctions.** An alternative approach to achieving the objectives of a CBAM could entail using joint renewable auctions, drawing on a practice already tested.

6.1 Introduction

Electricity is a good that merits special attention due to its physical characteristics. First, electricity flows are governed by Kirchhoff's laws[165], which makes tracking the original producer (and the implied carbon intensity) of a kWh imported into the EU challenging. Second, the EU is connected to its neighbours via interconnectors, which are subject to capacity constraints. This means that a CBAM on electricity cannot be compared to a CBAM on basic materials, such as cement or steel. This section lays out different possible CBAM approaches or alternative mechanisms for electricity.

A key element of electricity CBAM designs is the calculation of the effective CBAM rate and its ability to differentiate the carbon content of imported electricity. The calculation of this rate depends on the calculation of the carbon content of the electricity imported to the EU. This is not always straightforward. Four design options considered in detail in this chapter include:

- transaction-based approaches,
- marginal emissions-based approaches,
- average emissions-based approaches,
- joint renewable auctions.

[165] In an energy supplier-customer relationship, the best measurable unit of energy is its transmitted quantity. It is not (yet) completely measurable which customer consumed the energy from which source, because electrons or gas molecules cannot be directed in a network with multiple connections (Jong, 2018).

So far, there have been very few practical experiences and studies on border adjustments for electricity. Therefore, in this report the approaches are characterised on a conceptual basis, and then illustrated with experience from or analysis of existing or planned CBAMs.

In all design options, **we first take into account existing or future carbon prices in adjacent markets**. In order to avoid double taxation, the effective rate of the CBAM is determined by the level to which the EUA price exceeds the carbon price applied to the power sector in the adjacent territory (as long as no exceptions apply to foreign producers exporting to the EU).

Second, **we do not consider refunding carbon costs for exports**. In transaction-based approaches, it would otherwise allow for the attribution of coal power generation to exports, and thus result either in windfall profits for infra-marginal coal power generation or in additional coal power generation to serve foreign markets without the internalisation of carbon costs. We also exclude for the moment refunds for the approaches based on system values, because of the currently very limited demand for imports from the neighbouring countries, because it is not necessary to allow for mutual assistance of the power systems in emergency situations, because it would increase the MRV requirements to avoid fraud that is inherently more attractive with refund systems.

Third, unless explicitly stated in the text, it is assumed, that markets are efficiently coupled in the short-term, i.e. that an optimal dispatch of power plants is achieved. As in efficiently coupled markets the marginal power plant reacts to the additional demand (or supply) that is introduced via interconnectors, which is the main point of analysis. The analysis then focuses on the counterfactual situation of the respective CBAM for electricity as compared to no CBAM being introduced in the operational timeframe. The analysis thus explores options that may for several of the neighbours reflect a longer-term perspective of closer market integration. Other trading arrangements are explicitly discussed.

Fourth, it is important to note that none of the approaches can replicate the effect that the introduction of effective carbon pricing in the neighbouring countries, with a price level similar to that of the EU ETS, would have on overall emissions. The CBAM can only internalise carbon costs in exported electricity, as only the exports of the non-EU country are affected, but it cannot ensure that carbon costs are fully reflected in the merit order and cost structure of producing carbon-intense electricity in the non-EU country itself. Furthermore, imports missing due to an electricity CBAM need to be offset by additional production (or demand reduction) within the EU. Depending on whether the operational or investment timeframe is considered, and what the local potentials and carbon intensity for additional production within the EU are, overall emission savings can vary significantly.

6.2 Transaction-based approaches

Transaction-based approaches set the border adjustment on the emission intensity of individual transactions. This has the advantage of setting individual incentives for specific power plants, however, it also suffers from two drawbacks. First, it necessitates explicit allocation of physical transmission rights and nominations of power plants, rather than implicit market coupling mechanisms. Second, it suffers from the risk of resource shuffling, where existing low-carbon production is redirected to exports, and as a consequence emission-intensive production increases in the exporting country to serve domestic demand.

For implementation, the determination of the charge would be individually determined, and the burden-of-proof could, for example, be put on the importing contract party (with a high fallback option, in case of no documentary evidence). The statutory incidence could be on the importing contract party, or alternatively on the Transmission System Operator (TSO) receiving the nomination for the import flow within the EU. It could either be implemented as a charge, or by surrendering notional EUA allowances.

Table 6-1 Design elements of transaction-based approaches

	Transaction-based approaches
Emission basis	Emissions of specific transaction
Averaging	N.A.
Differentiation by	Power plant
Impact on dispatching via	Physical nominations
Determination of charge level	Individually determined per transaction (important party needs to provide evidence)
Collection of charge	• TSO receiving the nomination for the import flow • Contract party within the EU

California is the only jurisdiction that has currently implemented a CBAM as part of its climate policy framework and chosen a transaction-based approach. Based on a mandate set out in the Global Warming Solutions Act of 2006[166] the California Air Resources Board (CARB) launched a comprehensive emissions trading system in 2013[167]. Concerned about the economic and environmental implications of this measure, California included a statutory mandate to minimise emissions leakage[168]. In California, electricity importers – the "first deliverers" of imported electricity – are liable for the emissions associated with electricity generated in sources outside California. This is provided that the state does not have an emissions trading system linked to California's system[169]. Under these rules, all emissions reported for imported electricity from unspecified sources are considered to be above the coverage threshold, and subject to a default emissions factor multiplied by a transmission loss correction factor[170]. Because California forms part of a physically interconnected electricity system – the Western Interconnection – and imports around one third of its power from neighbouring states, this carbon border adjustment has acquired significant relevance in practice.

In California electricity importers – the "first deliverers" of imported electricity – are liable for the emissions associated with electricity generated in sources outside California. This is the case for

[166] A.B. 32, 2006 Leg. (Cal. 2006) (codified at Cal. Health & Safety Code §§ 38500–38599 (West 2011)).

[167] CAL. CODE REGS. tit. 17, §§ 95800–96023 (2011).

[168] A.B. 32, 2006 Leg. (Cal. 2006) (codified at CAL. HEALTH & SAFETY CODE §§ 38500–38599, § 38562(b)(8) (West 2011)).

[169] CAL. CODE REGS. tit. 17, § 95852(b): "First Deliverers of Electricity. A first deliverer of electricity covered under sections 95811(b) and 95812(c)(2) has a compliance obligation for every metric ton of CO_2e emissions calculated pursuant to section 95852(b)(1) for which a positive or qualified positive emissions data verification statement is issued pursuant to MRR, or for which there are assigned emissions, when such emissions are from a source in California or in a jurisdiction where a GHG emissions trading system has not been approved for linkage by the Board pursuant to Subarticle 12."

[170] CAL. CODE REGS. tit. 17, § 95812(c)(2)(B), reads: "Electricity importers. The applicability threshold for an electricity importer is based on the annual emissions from each of the electricity importer's sources of delivered electricity. All emissions reported for imported electricity from specified sources of electricity that emit 25,000 metric tons or more of CO_2e per year are considered to be above the threshold." Section 95812(d)(2) specifies that: "The threshold for an electricity importer of specified source of electricity is zero metric tons of CO_2e per year and for unspecified sources is zero MWhs per year as of January 1st 2015."

the states that do not have an emissions trading system linked to California's system[171]. Under these rules, all emissions reported for imported electricity from unspecified sources are considered to be above the coverage threshold, and subject to a default emissions factor multiplied by a transmission loss correction factor[172]. However, where power markets are more closely integrated through market coupling[173], the clearing algorithm would not be able to differentiate the sources of generation and their allocation towards domestic consumption. It can only, as in the non-transaction-based approaches, add a charge on all power imported to the EU from an adjacent region. This charge would therefore reflect the fallback value.

We consider two options for refunding this charge that reflect specified exports from power stations with lower carbon intensity than the reference value. First, EU market participants could report a bilateral financial contract reflecting the exports, but this is an unreliable indicator and may distort the market with unintended incentives. Hence it would be necessary to establish separate reimbursement rights that can be auctioned at the scale of available transmission capacity in a specified hour. Second, market participants could be requested to surrender certificates of origin for their power production in the exporting country. They could then be refunded where the certificate of origin certifies for the corresponding hour a carbon intensity below the default value applied in the market coupling algorithm. The outcome for market participants would be identical in all the instances under a competitive setting.

A concern specific to the transaction-based approach is resource shuffling. Here, the concern is that for exports to a territory with higher carbon prices, primarily production from low- or zero-carbon power plants will be nominated so as to avoid a carbon levy. In the case of California policy makers were hoping that resource shuffling would have a more limited role, because of pre-existing long-term contractual arrangements for power imports from specified plants in neighbouring states. However, it turned out that even in this situation resource shuffling did occur at large scale and entities did swap the related contract or ownership arrangement, and sell the electricity with higher carbon intensity in states without the emission constraints imposed in California[174]. Not only is this a particular form of leakage in the electricity sector that undercuts emission reductions in California, but it also allows electricity importers to avoid compliance with the CBAM provisions. While difficult to regulate, this practice has been addressed by updating the regulatory framework, which expressly proscribes resource shuffling, and sets out a detailed list of permitted ("safe harbour") practices[175]. This approach relies on effective monitoring and enforcement of the prohibition of resource shuffling of pre-existing contracts, something for which the experience to date has been mixed.

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[171] CAL. CODE REGS. tit. 17, § 95852(b): "First Deliverers of Electricity. A first deliverer of electricity covered under sections 95811(b) and 95812(c)(2) has a compliance obligation for every metric ton of CO_2e emissions calculated pursuant to section 95852(b)(1) for which a positive or qualified positive emissions data verification statement is issued pursuant to MRR, or for which there are assigned emissions, when such emissions are from a source in California or in a jurisdiction where a GHG emissions trading system has not been approved for linkage by the Board pursuant to Subarticle 12."

[172] CAL. CODE REGS. tit. 17, § 95812(c)(2)(B), reads: "Electricity importers. The applicability threshold for an electricity importer is based on the annual emissions from each of the electricity importer's sources of delivered electricity. All emissions reported for imported electricity from specified sources of electricity that emit 25,000 metric tons or more of CO_2e per year are considered to be above the threshold." Section 95812(d)(2) specifies that: "The threshold for an electricity importer of specified source of electricity is zero metric tons of CO_2e per year and for unspecified sources is zero MWhs per year as of January 1st 2015."

[173] As is the goal for countries within the Energy Community and thus many of the largest trading partners of the EU.

[174] See Meredith Fowlie and Danny Cullenward, Report on Emissions Leakage and Resource Shuffling, 10 September 2018, https://calepa.ca.gov/wp-content/uploads/sites/6/2018/09/6e.-IEMAC_Meeting_Materials_9-21-18__Fowlie_and_Cullenward_Report_on_Emissions_Leakage.pdf.

Qingyu Xu and Benjamin F. Hobbs (2020) Economic Efficiency of Alternative Border Carbon Adjustment Schemes: A Case Study of California Carbon Pricing and the Western North American Power Market, EPRG Working Paper 2032, affirms a high likelihood of resource shuffling under the current system design through application of a modelling framework.

[175] Cal. Code Regs. tit. 17, § 95852(b)(2) reads: "Resource shuffling is prohibited and is a violation of this article."

While this option has seen application in a practical context, offering valuable empirical evidence on the feasibility and impacts of a carbon border adjustment on electricity, it bears noting that the Californian context differs in significant ways from that in the EU, limiting the transferability of such insights. For instance, the Californian power market is dominated by long-term Power Purchase Agreements (PPAs), which help limit the incidence of dynamic resource shuffling through self-selection of new and future contracts for electricity sales into California. In electricity markets characterised by high shares of short-term transactions (day-ahead, intraday and real-time markets), such as that in place in the EU, a regulatory approach that proscribes resource shuffling would become virtually impossible to implement, as it relies on prohibiting changes to pre-existing long-term contracts with physical nominations. In the absence of the long-term physical arrangements, the least carbon-intensive power generation would be contracted for exports. As a result, it is likely that actual dispatch does not change, and thus does not lead to emissions reductions or the creation of a level playing field.

6.3 Marginal emissions-based approach

Marginal emissions-based approaches set the carbon border adjustment on the marginal emission intensity of the exporting system. In principle, this would set the correct emissions incentives for imports, i.e. imports would only happen at times when additional marginal foreign production, including the carbon price component is more affordable than (local) EU production. In practice, depending on the power market design and information available, simplifications are necessary, leading to several design options outlined in Table 6-2 below.

Table 6-2: Design elements of the marginal emissions-based approach

	Marginal emissions
Emission basis	Marginal emissions of power system
Averaging	Design options: • Hourly • Monthly • Yearly
Differentiation by	• Country-specific marginal systems emissions • Region-specific marginal systems emissions
Impact on dispatching via	• Clearing algorithms: Added on import prices • Implicitly via charges on imports
Determination of charge level	• Declared by TSOs / power exchanges (for hourly) • Determined by regulator based on historic values or modelling (for monthly to yearly periods)
Collection of charge	• Power exchanges running the market coupling algorithms (for implicit market coupling like congestion rent) • TSOs accepting physical nominations (physical transmission rights)

Source: DG ENER Consortium.

For the determination of system marginal emissions, a set of aspects needs to be considered.

First, the operating power station with the highest variable operational costs on the system may be considered the marginal power station. In most systems, available nuclear, wind, and solar generation is always utilised and then the remaining demand met with fossil generation. Hence the marginal plant is typically a fossil plant. If coal or gas generation capacity is available, then this will typically serve the additional power need. In principle, this should be the marginal plant to determine the carbon intensity of marginal power generation.

Second, system operators require sufficient flexibility to accommodate for expected and unexpected changes in net demand. For this reason, they may retain coal and gas power stations on part-load or jump-start open cycle gas turbine power stations. This flexibility requirement – largely unrelated to the scheduled export – may result in an increased carbon intensity due to part-load operation of plants, or lower carbon intensity, due to the use of flexibility of gas power stations, than additional pre-scheduled generation that may actually trigger for example additional coal power generation. These additional scheduling considerations for the provision of additional flexibility should therefore not be considered for determining the carbon intensity of marginal power generation for scheduled power export.

Third, with increasing penetration of wind and solar power, especially smaller power systems with large shares of renewable power, generation may exhibit an increasing number of hours in which wind and solar power production exceeds demand and hence excess wind or solar power generation will be curtailed. For the time being, power system operators would still retain some fossil generation assets on the system in such hours to secure sufficient inertia, fault ride through capacity and to accommodate ramping constraints. Hence despite the operation of fossil plants, in such hours the marginal carbon intensity of exported power should be considered zero.

Fourth, existing hydro storage capacity and increasing sources of new flexibility options can allow for the transfer of "surplus" renewable generation to other hours in which fossil generation can be replaced. Thus, if there is no wind or solar spill in hours without fossil power generation, marginal carbon intensity of additional power demand, e.g. due to exports, would reflect carbon intensity in hours with fossil generation in which the stored energy will be used to replace fossil generation. However, storage capacity is typically limited and will be more so with the increasing variability of power generation from wind and solar power.

What does this imply for the determination of marginal carbon intensity?

Using observed power generation. Even if hourly power generation at the plant level and the respective marginal generation costs are collected, it would be inappropriate to determine the marginal carbon intensity based on the carbon intensity of the plant with the highest variable operating costs. This plant may merely provide short-term flexibility or system services (point 2 above).

Using dispatch modelling. A dispatch model of the power system should in theory be in a position to replicate the system outcome. Such a dispatch model could also be used to compare the outcome with and without the additional power demand from exports (at marginal level or at the full export volume). However, in practice the parametrisation of all technical constraints of generation assets, grid topology, market imperfections and dispatch heuristics in such a model is tricky – and could cause large-scale disputes if the outcome would be used to determine revenue for (state owned) power generation assets.

Using a simplified heuristic. EU power market regulation has a long (and mixed) track record of applying simplified heuristics to determine cost allocation and operational choices in the absence of sufficient data, methodology or harmonised procedures. For example, allocation of transmission costs to cross-border flows and the transmission capacity made available for cross-border flows are based on simplified heuristics.

A simplified heuristic could, for example, be based on the average carbon intensity of the fossil power generation fleet only for all hours in which there is no wind and solar curtailment caused by energy surplus at the national level. The underlying reasoning is that due to the low operational (zero) cost of low-carbon technologies, these are usually running irrespective of exports or not, whereas the additional power is usually provided by fossil power plants. This even holds true for significant amounts of hydropower in the system, as these are usually constrained in their production over the year (very little water is spilled), so that power for exports needs to come from additional fossil generation. For neighbouring systems with very high shares of renewables, special provisions could be introduced: For hours of such nationwide wind and solar curtailment of non-EU markets, the carbon intensity could be assumed to be zero, as exports could reduce the curtailment and not lead to additional fossil production. It may need to be considered, if it is possible to also identify hours in which only the availability of export capacity avoided the need for wind-spill and in this case treat these hours equivalently.

For an example of such an implementation of a heuristic see current indirect cost compensation guidelines (2012/C 158/04). The heuristic would thus abstract from the sophisticated operational requirements mentioned under point 2 above and rely on historically available data (thus implying a one-year delay). It may be necessary to test in modelling runs for relevant neighbouring countries, to what extent the simplification with respect to variance of carbon intensity across plants is appropriate.

Temporal averaging determines how fine-grained the economic incentives are set, and in principle a higher resolution is better, as (yearly or monthly) averaging will either under-price emissions from the highest emitters (when marginal), or overprice emissions from lower carbon emitters (when marginal). This would result in the wrong marginal incentives for production for export purposes to the EU. However, hourly marginal emissions are difficult to impossible to calculate precisely for now and implicit market coupling algorithms are probably necessary to apply this mechanism at such a resolution.

The above-described heuristic based on an average marginal emission value applied to all hours but the hours with wind and solar curtailment for energy balance reasons in the exporting country, might offer a balanced solution. Average annual marginal emissions could be approximated from common (backward-looking) energy statistics. Should seasonal variations in some countries have significant impact on the average carbon intensity of the fossil generation mix, then a monthly average value might be considered.

The network topology may also need to be considered. Where adjacent countries are part of a strongly meshed system with other neighbouring countries, like for example in the Western Balkans, the marginal power plant (or the system marginal emissions) may lie outside the country directly connected to European networks. In such a case, instead of determining the emission factor of the directly connected country, the emission factor of the larger connected price region may be applied. This approach could mirror approaches applied within the EU to determine for example the EU ETS power price compensation based on average carbon intensity factors for regions like Central Western Europe, Central Eastern Europe or the Iberian Peninsula, that have a sufficient level of price convergence.

Determining the level of the obligation could be rather controversial and requires careful considerations. A set of institutional options may be considered and described on the basis of the examples (not necessarily linked to CBAMs) below.

First, in Poland the revenue for generation assets in the national power market involves a comparable counterfactual simulation. In this case, the Transmission System Operator (TSO) determines the market clearing price that would result with or without transmission constraints, operates the system obviously based on the transmission constraints, but compensates generators that are not called on due to transmission constraints, based on the counterfactual simulation. The agency problem is addressed, because the nationally regulated TSO is responsible for compensation payments within the country. With increasing integration of the power systems particularly due to higher renewable penetration, there may be the prospect of a joint institution taking responsibility for the potentially controversial calculation.

Second, in the case of the New York a different solution may come in to play (See Appendix 4: Electricity CBAM – insights from the New York State proposal for details of the case]. New York is considering applying a counterfactual simulation without a carbon price to determine the level of carbon border adjustment for power imports. The clearly defined market clearing algorithm for the nodal pricing system operated by the New York ISO and the codification of the tacit knowledge otherwise core to power system operation within this clearing algorithm, limits the level of the discretionary choices remaining for the ISO, and hence may increase the trust of all actors, including from adjacent states, in the result.

Third, in the short-term such sophisticated solutions may not be available, and hence a simplified heuristic can then be applied with very limited discretionary choices by an agency. This would require codification of the heuristic in the proposal, preferably following a joint process of exploration and consultation. To facilitate a further refinement following, for example, the two options outlined above, it may already be desirable to incorporate guiding principles for any further revisions.

Collection of the charge. Depending on the arrangements under which power is traded with the neighbouring country, the charge (or obligation for surrender of notional allowances) would be implemented.

Where markets are linked through implicit market coupling, a mechanism is already in place to collect congestion revenue through the power exchanges. Their mandate could be expanded to collect the revenue from a CBAM or to acquire notional allowances to meet the obligation for surrender of notional allowances.

Where market participants need to acquire physical transmission rights to import power to the EU, this already involves the requirement to nominate hourly import flows to the respective TSO. It may be warranted to link the liability for surrendering a charge or notional allowances to the nomination of the import flows, rather than to the auctions as not all transmission capacity acquired in auctions will be used for imports (often base load bands are auctioned), because auctions happen often more than one year before the transmission takes place and could thus preclude shorter-term adjustments of the applied value and the differentiation between hours with and without wind/solar spill. As the import flows are nominated to the TSO, the TSO could be requested to levy the charge or notional allowances for the nominated flows.

6.4 Average-emissions based approaches

Average-emissions based approaches set the carbon border adjustment on the average emission intensity of the exporting (or in a variation the importing) system. A conceptual proposal was outlined by a European think tank and advocacy group, Ember (formerly Sandbag), based on annual average emissions, and added on imports. This will on average under-price emissions of neighbouring markets, as under economic dispatching it is the marginal unit in the exporting country that will need to increase its output to achieve exports. These units are usually coal- or gas-fired power plants, whereas the average emissions also include low-carbon power plants such as nuclear power, renewables or hydro power, which usually run at their maximum capacities regardless of exports (see the section on average marginal emissions, for a more extensive discussion). As a result, the average-based emissions approach only partially addresses carbon leakage risks, since imports from marginal (polluting) generators would on average be subject to lower carbon costs than EU generators.

Table 6-3 Design elements of average-emissions based approaches

	Average emissions
Emission basis	Average emissions of power system
Averaging	Design options: • Monthly • Yearly
Differentiation by	• Country • Price region
Impact on dispatching via	• Clearing algorithms: Added on import prices • Implicitly via charges on imports
Determination of charge level	• Regulatory determined
Collection of charge	• Power exchanges running the market coupling algorithms (for implicit market coupling like congestion rent) • TSOs accepting physical nominations (physical transmission rights)

Source: DG ENER Consortium

Further design considerations are also affected by the performance of the mechanism, and mirror those for marginal emission-based approaches. Therefore, the main similarities and differences are highlighted here. Similar to the marginal-based approach temporal averaging makes implementation easier, but leads to a coarser impact. Currently, data for the yearly average is readily available, whereas monthly or hourly data may not be available in sufficient quality. In contrast to the marginal emissions approach, such factors could also be based on observed generation, as the challenge of identifying the marginal unit can be disregarded. The added value of an analysis with a dispatch model is very small, as the averages can be robustly estimated from energy statistics, or otherwise from observed generation.

The network topology may also be considered. Where adjacent countries are part of a strongly meshed system with other neighbouring countries, like for example in the Western Balkans, instead of determining the average emissions of the directly connected country, the average emissions of the larger connected price region may be applied. This approach could mirror approaches applied within the EU to determine for example the EU ETS power price compensation based on average carbon intensity factors for regions like CWE, CEE or the Iberian Peninsula, that have a sufficient level of price convergence.

Determining the level of the obligation would be less controversial than for the average marginal emissions approach, as at least for the yearly average sufficient data is available and a robust estimation of average emissions is feasible. Monthly historic statistic may, depending on the country, be equally available, and be sensible to implement if strong seasonal components in the generation mix exist. Otherwise for an hourly implementation the support of TSOs or power exchanges would be needed, which may create agency problems. Collection of the charge: depending on the arrangements under which power is traded with the neighbouring country, the charge (or obligation for surrender of notional allowances) would be implemented and would mirror the implementation for the average marginal emissions approach.

Where markets are linked through implicit market coupling, a mechanism is already in place to collect congestion revenue through the power exchanges and common clearing houses. Their mandate could be expanded to collect the revenue from a carbon charge or to acquire notional allowances to meet the obligation for surrender of notional allowances.

Where market participants need to acquire physical transmission rights to import power into the EU, this already involves the requirement to nominate hourly import flows to the respective TSO. It may be warranted to link the liability for surrendering a charge or notional allowances to the nomination of the import flows, rather than to auctions, as not all transmission capacity acquired in auctions will be used for imports (often base load bands are auctioned), because auctions happen often more than one year before the transmission takes place and could thus preclude shorter-term adjustments of the applied value and the differentiation between hours with and without wind/solar spill. As the import flows are nominated to the TSO, the TSO could be requested to levy the charge or notional allowances for the nominated flows.

The effect on avoiding carbon leakage risks is inherently limited, as a charge based on the average emissions usually under-prices the emissions of the marginal exporting power plants. Hence incentives remain to substitute EU domestic production with carbon-intensive imports, resulting in carbon leakage.

6.5 Joint renewable auctions

An alternative approach to achieving the objectives of a CBAM could entail using joint renewable auctions, drawing on a practice already tested between different Member States as described below.

The intention of the mechanism is to avoid additional production of carbon-intensive power in neighbouring countries. However, because of resource shuffling it is likely that any requirement that aims to encourage the sale of clean power to the EU will merely result in a re-allocation of existing power generation capacities (Option 1). As variable renewables are nearly always running due to low (to zero) variable costs, an increase in exports will come from production from other generation capacity (e.g. fossil fuels). This is an inherent challenge if incentives for clean demand are primarily linked to short-term exports of power and if a significant share of the maximum power that can be exported may be served by existing clean domestic production capacity.

It may be warranted to explore alternative avenues towards achieving the policy objective of ensuring the additionality of clean power exports to the EU from neighbouring countries. One option could be the development of additional renewable power in neighbouring countries at a scale of available transmission capacity. If power is then imported to the EU, then this power import does not create additional carbon emissions in the neighbouring country compared to a counterfactual without transmission and without the renewable generation. The renewable cooperation mechanism might be an effective tool to achieve such an objective. Countries like Germany and Denmark have already successfully implemented so-called joint renewable auctions. These are tenders for renewable projects in one country (in this case Denmark) with the renewable power production credited in equal shares towards the renewable targets of both countries. Such an auction could in principle also be applied with EU neighbours. The EU Renewable Energy Directive would in this case require that the power generation that is to be credited to an EU Member State renewable target also be physically delivered to the EU.

A joint renewable auction would offer the neighbouring country the benefit of economic activity linked to the development and subsequent maintenance of a project, and could be structured such that the entire project would benefit from the improved financing provisions typically available to EU Member States. The EU Renewable Energy Directive implies that only joint auctions up to an EU power share corresponding to the physical transmission capacity can be implemented. To this extent, access to this transmission capacity could be granted as a physical transmission right to the renewable project (in the absence of an integrated coupling algorithm). To the extent that this transmission capacity is scarce, the value of capacity would be granted to the project. As a result, the costs of renewable power production of the project would decline to the shared benefit of electricity consumers in the EU and the neighbouring country.

The physical transmission right would have to be released to the market whenever it is not required due to lack of wind or solar generation. To the extent that such a release is only pursued on short notice, the capacity can only be utilised by flexible generation, storage and demand options. This could, in principle, ensure incentives for such flexibility options, which are considered important in the transition of the power system towards increased shares of wind and power generation. Additional analysis is, however, required to assess whether this assumption holds or whether additional rules for the use of the released transmission capacity may need to be considered.

The key design options are: the amount of renewables capacity suitable for current and extending transmission capacity, and in the case of physical transmission rights, how they are allocated and potentially released to other market participants. To assess the overall effect, a modelling simulation is warranted.

Its effectiveness in avoiding carbon leakage depends on the trading arrangements and accompanying measures. As described above, if markets are not implicitly coupled, trading arrangements could be organised in such a way as to mitigate carbon leakage. If, however, implicit market coupling is in place, carbon leakage would only be partially be mitigated, e.g. because financial transmission rights are not available to hedge base load exports from fossil generation. This would increase the risk and therefore costs of exporting fossil-based power generation, and hence reduce re-investments.

Combining joint renewable auctions with an import charge-based approach could be considered as an alternative. This could address the difficulty of granting exemptions from default values on import charges for individual transactions, as described in the transaction-based approach, and at the same time be more specific than adjusting the default value for specific regions. Instead, exemptions from the default value could be granted for specific investments in low-carbon projects in neighbouring countries. These could involve (i) granting transmission rights in combination with a waiver for the export profile of a specific investment (e.g. wind or solar park) and (ii) granting a waiver for import carbon charges for this investment. To ensure access to such “benefits” is transparent and non-discriminatory also in case where the scale of investment projects exceeds the transmission capacity, a joint renewable auction could be implemented.

6.6 Assessment of options

In the following, an initial assessment of options is provided. The assessment is only pursued for a limited number of all potential design options. More specifically, only hourly and yearly averaging where assessed. As outlined above, monthly averaging may be warranted in systems with large seasonal variations on carbon intensity of (fossil) generation mix, but would otherwise perform equivalent to annual averages.

The assessment is reported in absolute terms, and we thus include an assessment of the status quo to allow for a comparison.

The criteria for the assessment are based on the overall criteria defined in Chapter 4 for industry CBAM options.

- Primary objective 1 (Support the EU's transition to climate neutrality) is not discussed as criteria, because it is considered that this is already achieved in the power sector. Due to limited interconnection capacities with third countries, full auctioning of allowances has been implemented since 2012 and results in a consistent carbon price for all actors in the EU power system.
- Primary objective 2 (Avoid carbon leakage risk) is discussed both with respect to carbon leakage risk from marginal units i.e. an increased import to the EU results in an increase of fossil-based power generation in a neighbouring country and to carbon leakage risks from resource shuffling, i.e. in neighbouring countries the opportunity of benefiting from reduced border charges by attributing low-carbon power generation to exports triggers additional export volumes which in turn trigger additional power generation and associated emissions to meet domestic demand.
- Secondary objective 1 (International climate action) is discussed with respect to incentives for green production and investment abroad.
- Secondary objective 2 (Revenue generation) was so far not quantified but may be informed by later modelling exercises.

Requirement 1 (Practical feasibility) is discussed as final criteria with respect to technical and administrative feasibility.

Table 6-4: Assessment of power CBAM and alternative policy design options

Policy option	PO2: Carbon Leakage risk from marginal unit	PO2: Carbon Leakage risk from resource shuffling	SO1: Incentives for green production & investment abroad	R1: Practical feasibility
Business As Usual	**High**	**Low**	**Medium,** as there are higher prices for all players in foreign market, due to exports to EU (including polluting plants)	**-**
Transaction-based approach	**Low**, since transaction-based	**High**, as contracts are reassigned to existing low-carbon production	**Low** (with resource shuffling), **High** (if resource shuffling effects are excluded)	**Low to Medium** (depending on coupling mechanism)
Marginal emissions-based approach – Hourly*	**Low,** as charged according to marginal plant	**Low**, as applies to all imports uniformly	**Medium,** exist only if low-carbon units are frequently marginal	**Very Low** (due to EU market design and additional difficulty of data on hourly marginal emissions in other countries)
Marginal emissions-based approach – Monthly/Annual*	**Medium,** with only moderate risk of under-pricing marginal high-carbon foreign plants that exceed the average	**Low**, as applies to all imports uniformly	**Low,** as low-carbon units are overpriced due to averaging over time **Medium**, with adjustment for hours of system-wide surplus of wind/solar generation	**Medium to High**
Average emissions approach – Monthly /Annual*	**Medium to High,** as average emission factor is usually significantly below marginal emissions	**Low**, as applies to all imports uniformly	**Medium,** as there are higher prices for all players in foreign market, due to exports to EU	**Medium to High**
Joint Renewable Auctions	**Low to Medium,** if physical transaction rights for RES reduce imports from high-carbon plants **Medium to High,** if implicit market coupling is applied and no other	**Low,** as only new investments receive contracts	**High,** as directly triggering investments	**Medium** (dependent on whether physical nominations are feasible)

	CBAM applies			

(*) In these options, the marginal/average emission factor is applied to all imports irrespective of the actual emission intensity of the exporting plant.

7. CONCLUSIONS

The European Union strives for climate neutrality by 2050. Reaching this goal will require a profound transformation through efficient and climate-neutral production processes, efficient use and choice of materials as well as recycling. The EU considers pricing of carbon emissions as an important instrument of the policy package. Yet the prices charged for greenhouse gas (GHG) emissions differ internationally, which creates a risk of carbon leakage (i.e. a risk of increasing emissions in third countries where industry would not be subject to comparable carbon constraints). The EU ETS currently addresses this risk by granting free allowances and compensation for indirect carbon costs to producers in sectors at risk of carbon leakage. The approach comes at a high price, as the measures weaken the impact of the carbon price to foster innovation in low-carbon technology and resource efficiency. The impact is also not consistent across products, because the effective share of priced emissions differs.

Objectives of CBAMs

Carbon Border Adjustment Mechanisms (CBAM) adjust for international carbon price differences at the border so that products entering the European Union face similar levels of carbon pricing as similar domestic products. **One primary objective** of CBAMs is to support the reduction of GHG emission in the European Union and ultimately its path to climate neutrality by helping to ensure that all industrial activities face incentives to reduce EU greenhouse gas emissions. Thereby, CBAMs can be expected to make a significant contribution towards the achievement of the EU's Green Deal objectives, including inducing the investments that put Europe on an emission pathway towards climate neutrality by 2050. **Another primary objective** of CBAMs is to ensure that emissions reductions in the EU lead to emissions reductions globally. The global benefits from the EU's increased climate targets should not be defeated by the unintended consequence of an increase of emissions outside of the EU. As long as carbon price differentials persist internationally, a rise in costs for carbon emissions in the EU could create the risk that greenhouse gas emissions from carbon-intensive production would be relocated to other regions rather than avoided by a shift to climate-neutral production processes, climate-friendly material use and enhanced recycling. Adequately addressing concerns about carbon leakage risks is thus essential to enhance regulatory credibility of the EU ETS and the resulting carbon price. Complementing these objectives of a CBAM is the requirement of ensuring practical feasibility and limiting the administrative burden for all actors involved and affected by such a mechanism. Moreover, while an assessment of international legal obligations such as WTO rules have been outside of the scope of this study, the options have been designed to reflect international obligations to the best extent possible.

Options for a CBAM and alternative measures

To achieve these objectives, a variety of proposals for a CBAM to complement the EU ETS have been made in the scholarly literature and the political discourse. In order to map the policy space without conflating the complexity, we work with five options, with the first option coming in two sub-options, as follows.

- **Options 1a and 1b**: a CBAM on imports of carbon-intensive materials with full auctioning. Option 1b differs from Option 1a in that the former works with a fixed reference level for carbon emissions, whereas under the latter importers have the possibility to demonstrate that actual emissions were lower.
- **Option 2**: a CBAM on imports of carbon-intensive materials complementing free allocation.
- **Option 3**: a CBAM on imports and exports of carbon-intensive materials including as part of products.
- **Option 4**: A combination of an excise on carbon-intensive materials with a CBAM and continued free allocation.
- **Option 5**: Carbon added tax including a CBAM.

Assessment of the Options

Based on the literature, qualitative arguments and some quantifications, the study has assessed the business as usual (BAU) scenario of continued and declining free allocation and the different design options of a CBAM approach against the policy objectives[176]. The study has found a **clear case for complementing the EU ETS with a CBAM or alternative measure.** There are two main reasons for this. First, the carbon price is currently not fully consistent due to free allowance allocation. This results in strongly reduced carbon price incentives for material efficiency, recycling (cement, plastic), and clean processes. Second, although free allocation might be sufficient to mitigate carbon leakage risk in the short term, without any complementary measures a declining EU ETS cap in the context of increasing EU climate ambition would erode the carbon leakage protection in the medium term.

CBAMs on imports of carbon-intensive materials with full auctioning (Options 1a and 1b) perform better than the BAU scenario in terms of carbon price incentives due to the move to full auctioning. However, the competition from imports of components and finished products weakens the ability to pass through costs along the value chain. Option 1a eliminates resource shuffling risks as importers cannot deviate from default values (reference values). Imports are thus burdened independently of the actual production processes. Option 1b, on the other hand, allows importers of basic materials to demonstrate that their individual production process is more efficient than the reference value. This, however, opens the door for resource shuffling concerns (see also Appendix 2: Stakeholder consultation results).

Under both Options 1a and 1b, downstream products are not covered by the CBAM, which might lead to carbon leakage. Importers of competing foreign products would not face the same carbon costs as European producers. The resulting competitive advantage could be mitigated to some extent by including product groups with high relative cost increases due to a consistent carbon pricing. Due to the lack of relief for exports under Option 1, this would only work where value chains of the production processes are not integrated across borders, since the carbon content of the products would otherwise be charged more than once.

Finally, the lack of relief for exports implies that European exporters along the value chain would be subject to carbon leakage risks in Option 1, since they would face competitive pressure from foreign producers whose products are not subject to equivalent carbon costs. As the analysis in Section 3.4.2 has shown, a large number of industries would be affected by high relative cost increases even under a relatively moderate carbon price. Moreover, a significant share of basic materials and basic material products is exported in most sectors. Consequently, in the stakeholder consultation, industrial stakeholders from all economic sectors raised major concerns about the lack of coverage for export. The carbon leakage risk for exporters cannot be mitigated under Option 1.

A CBAM on imports of carbon-intensive materials complementing free allocation (Option 2) could only be envisaged as a transition approach. It keeps the disadvantages of free allocation, without reaping the full benefits of a well-designed CBAM. While it might be viewed as a short-term solution to carbon leakage risks by continuing free allowance allocation, the carbon leakage risks identified in Option 1 will resurface as soon as free allocation is phased out, since Option 2 then converges to Option 1b. Moreover, it does not provide the consistent carbon pricing signals needed for investments into climate-neutral production processes. Finally, both Options 1 and 2 are not compatible with multiple countries using the system in parallel due to the lack of an export reimbursement, unless the carbon price paid abroad is deductible in the destination country.

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[176] See Table 38 for a summary assessment of the impact of all options.

A CBAM on imports and exports of carbon-intensive materials including as part of products (Option 3) combines full carbon price incentives for carbon-intensive materials and manufactured goods sold domestically with, in principle, sound carbon leakage protection. However, as importers are allowed to deviate from the reference values, there are incentives for resource shuffling that could erode leakage protection. The main concern relates to the refund of incurred carbon costs for exports. This implies that there are incentives for exporting European production with a higher carbon intensity. Such resource shuffling lowers revenues from the CBAM, and incentives to reduce emissions. It thus undermines the intended environmental objective. Application of default values for the maximum refund granted could reinstate incentives for carbon efficiency improvements of inefficient plants, but not for investments in clean production processes. Moreover, concerns about administrative complexity have arisen in the stakeholder consultation in case of a wide product coverage along the value chain. Consequently, coverage of products along the value chain could therefore be limited to the sectors where a full carbon cost pass-through would induce significant production cost changes (see Figure 3-1).

An excise including a CBAM on carbon-intensive materials including as part of products and continued free allocation (Option 4) performs well across the various objectives and criteria, on consistent carbon pricing as well as, albeit not perfectly, avoiding carbon leakage risks and resource shuffling. The excise is levied independently of origin and of production methods. Therefore, it would be possible to apply more estimation methods and simplifications in the determination of embedded emissions, and wider product groups could be assigned for the same reference value. The effort for setting up the system would therefore be smaller in this regard, although it is expected to raise significant administration costs, while also raising significant revenue. Although it does not create incentives for international producers for a less carbon-intensive production, this is the flip side of the coin for avoiding both resource shuffling incentives and extraterritorial tracing and verification. Stakeholders regarded the excise as providing an attractive investment framework into climate-neutral production processes.

A carbon added tax including a CBAM (Option 5) may seem attractive with its wide scope, but appears not feasible in practice because of the very extensive domestic and international monitoring, tracking, attribution and verification requirements, implying significant administrative efforts for all parties involved. This was confirmed by the stakeholder consultation. Otherwise, the option has full carbon incentives for domestic production, but similarly to Option 3 resource shuffling is a concern domestically and internationally. Resource shuffling may also undermine the environmental credibility of the refund of incurred carbon costs, which could result in a continued operation of European carbon-intensive assets for the purpose of exports.

<u>Definition of products covered by the CBAM</u>

To define products to be covered by the CBAM, we evaluated the relevance in terms of emissions (i.e. whether the sector is a significant emitter of greenhouse gases, and whether there is an emission reduction potential) as well as exposure to a significant risk of carbon leakage (as defined pursuant to the EU ETS Directive). **Furthermore, practical arguments were taken into consideration, in particular whether a material or product class can be clearly defined, and whether materials or products can be unambiguously identified in practice** when the level of CBAM obligation needs to be determined. This poses an inherent challenge when the same basic material products can be made of primary or secondary (i.e. recycled) materials. Differentiation can create incentives for resource shuffling, and where distinction is difficult to monitor, it may encourage fraud. The most prominent case here are metals in general, which can be easily recycled, and in particular the different production routes blast furnace (primary) and electric arc furnace (almost exclusively secondary) steel. **Finally, it is essential that an appropriate default value for the**

emission intensity level (the "embedded emissions") of the materials or products included can be defined. The level of precision required differs: for an excise a rough estimate may be sufficient, while a design option imposing the default value only on international trade, using actual values on emissions intensity will require default values which are robust. For options which require or allow the use of actual emission intensity levels, robust and feasible rules for monitoring, reporting and verification are required.

Based on these three criteria, we find that for a first phase cement, iron and steel, aluminium, fertilisers and polymers could be included in the coverage. Note that "polymers" are a borderline case, as their inclusion depends on the technical possibility of defining reference values for embedded emissions, which may be easier for option 4.

Embedded emissions

The CBAM approach is based on "embedded emissions" of materials. The Monitoring, Reporting and Verification of these embedded emissions are important elements of Options 1-3. The excise under Option 4 would only require simpler approaches at the border (merely tracking material flows to apply default values) but more monitoring of material flows within the European Union.

Without a robust MRV system, there would not be any trust by stakeholders in the system. Since detailed emission reporting rules in various carbon pricing instruments are quite different regarding their technical details, it would be crucial to make data quality comparable for all possible CBAM imports. For this purpose, the CBAM should require that minimum rules defined for this purpose have to be followed. They would be largely in line with the EU ETS. To the extent feasible, the rules could be made more "international" by using references to ISO standards wherever they are sufficiently in line with EU ETS / CBAM requirements.

For reliable data on embedded emissions from materials produced in non-EU installations, Options 1-3, where they allow the importer to use actual emission values, would require that installations selling materials into the EU market have a documented and site-specific monitoring methodology in place. Where there is no mandatory carbon pricing system in place which would facilitate an approval by a competent authority (CA), an independent verifier would validate the methodology which would henceforth to be followed. This approach is similar to the one used in CDM[177] projects and is therefore considered feasible in principle, although the complexity of the required monitoring may be higher for the CBAM. The operator would provide annual emission reports containing information not only about the whole installation's emissions and production levels, but also the embedded emissions at a level of disaggregation required for use in the CBAM. An independent verifier would verify the emission reports. In order to ensure the qualification and competence of verifiers, accreditation of the verifier by a European National Accreditation Body (NAB) in line with the AVR's requirements would be mandatory. The emission report (if positively verified) would then be registered and made available in a European database (termed "CBAM facility" in Section 5.4.1). The embedded emissions determined on the basis of that emission report would remain valid for a year, until a new verified emission report is registered.

Climate policy in third countries

Various options to adjust CBAM levels for climate policy in a third country were discussed. The carbon price applicable to emissions from the industries in the third country is the most feasible (or least infeasible) option to recognise the relative stringency of third-party climate policies in a CBAM. The carbon price (as it applies to industrial emissions) provides a unified, relatively robust and comparable metric. To the extent that the effective carbon price

[177] Clean Development Mechanism.

for relevant industries in other jurisdictions can be determined to a reasonable level (e.g. by means of an open policy dialogue with like-minded countries), it could be used to adjust the level of the CBAM obligation for various countries. Exemptions from the carbon price or free allowances granted would need to be taken into account, which illustrates how difficult a detailed consideration of a carbon price would be.

In terms of exempting imports from certain groups of countries, exemptions for LDCs and exemptions for imports from linked carbon markets need to be distinguished. While the exemption would be without alternative in the case of linking, a blanket exemption for trade with all LDCs could become problematic, as it could induce LDCs to move toward more energy- and emission-intensive processes. Instead, it may be considered whether part of the revenue from any CBAM mechanism could be used to support a just transition towards climate-friendly material production also in LDCs and selected emerging economies.

Compliance and enforcement costs

Compliance and enforcement costs were approximated for the main options under consideration. They are incurred by businesses to comply with rules and obligations, and by authorities to administer the mechanism and ensure the rules are respected.

Option 1a would be an option resulting in comparatively low costs as it relies fully on default values. Under the assumptions applied in this compliance cost assessment, the total yearly costs amount to EUR 3.95 million for an import tax or between EUR 3.96 million and EUR 5.03 million for notional EU ETS allowances. **Option 1b** would result in higher costs, because the CBAM based on actual emission values creates monitoring, verification and reporting costs for businesses in the EU. The estimated total annual costs for this option amount to between EUR 9.8 million and EUR 13.2 million for an import tax or between EUR 9.8 million and EUR 14.3 million for notional EU ETS allowances. **Option 2** would result in similar costs, depending on the use of default values or the possibility to claim actual embedded emissions. The same applies to **Option 3**. However, the further depth of the value chain adds considerably more relevant installations, importers, and import transactions. This increases the compliance costs compared to similar designs only targeting basic materials (and basic material products). **Option 4**, which takes the approach of introducing an excise, is estimated to result in relatively low unit costs but higher total costs because of the larger number of businesses obliged. The total for this option is estimated between EUR 14.7 million and EUR 28.7 million.

Considering the volumes of imports of all sectors considered in this study, the **compliance cost per tonne of import (Options 1a or 1b) or per tonne covered by the excise duty system (Option 4) would be very low** for import mechanisms using default values or an excise-based system. For an import mechanism using actual emission values, the costs per tonne would be slightly higher but still at a very low level of between 10 and 38 euro cents per tonne.

Enforcement costs for authorities are driven by similar factors as are compliance costs for businesses. **Option 1a** creates lower costs, estimated at EUR 9.3 million for import tax and EUR 10.3 million for notional ETS allowances, than options using more accurate emissions as reported by importers based on the monitoring in the production sites (**Option 1b**, EUR 14 million for import tax and EUR 15 million for notional ETS allowances). The options of import tax and notional ETS allowances share many cost elements and have overall comparable costs. The main difference is the administration of payments.

The implementation in coexistence with free allowance allocation under the EU ETS (**Option 2**) would result in similar costs for authorities as Options 1a or 1b, depending on the choice between default values or actual emission values. For all these cases, the expansion of the scope to products of downstream processes or providing rebates to exports (**Option 3**) would increase the number of importers (or also exporters) and therefore result in substantially higher costs. The importers of products of downstream processes but also exporters of basic materials from the EU are in the main different businesses than those importing the basic materials and basic material products under the narrower CBAM. The broader scope would increase the number of cases and in consequence the enforcement costs. As before, an excise duty (**Option 4**) differs from the border instruments mentioned in the previous paragraphs. While the use of default values reduces the overall administrative and compliance costs, this effect is compensated by the broader product coverage, resulting in an approximated overall enforcement cost level similar to Option 3.

A. APPENDICES

Appendix 1: Overview of options discussed in this report

3.3.2.1.”Main options” as discussed in Chapter 3:

0. BaU: Business as usual, EU ETS with continued and declining free allocation
1. Options 1a and 1b: CBAM on imports of carbon-intensive materials with full auctioning
   a. 1a: CBAM on imports at a reference level
   b. 1b: CBAM on imports at the level of actual emissions
2. Option 2: CBAM on imports of carbon-intensive materials complementing free allocation
3. Option 3: CBAM on imports and exports of carbon-intensive materials including as part of products
4. Option 4: Excise including CBAM on carbon-intensive materials including as part of products and continued free allocation
5. Option 5: Carbon added tax including CBAM

	CBAM on imports with full auctioning (Options 1a and 1b)	**CBAM on imports complementing free allocation (Option 2)**	**CBAM on imports and exports (Option 3)**	**Excise including CBAM and free allocation (Option 4)**	**Carbon added tax including CBAM (Option 5)**
Emissions covered	Production of basic materials (direct and indirect)	Production of basic materials (direct and indirect)	Production of basic materials (direct and indirect)	Production of basic materials (direct and indirect)	All emissions along value chain
Scope of CBAM (depth of value chain)	Only basic materials and basic material products	Only basic materials and basic material products	Basic materials also as part of manufactured products	Basic materials also as part of manufactured products	Basic materials and manufactured products
Carbon price on exports	Yes	Yes	No	No	No
Free allocation in the EU ETS	No (full auctioning)	Yes (partially retained)	No (full auctioning)	Yes	No (full auctioning)
Mode of payment	Domestic producers buy allowances, importers buy (notional) allowances or pay tax	Domestic producers buy allowances beyond free allocation, importers buy (notional) allowances or pay tax	Domestic producers buy allowances, importers buy (notional) allowances or pay tax	EU ETS coverage plus liability created upon production and import, paid when product leaves duty suspension regime	EU ETS coverage plus payment of tax for additional emissions at each production step, imports at reference value or actual emissions
Reflection of actual emissions in carbon pricing	Yes for domestic production, reference value (Option 1a) or verified emissions for imports (Option 1b)	Only partially for domestic production, reference value or verified emissions for imports	Yes for domestic production, reference value or verified emissions for imports	Yes for domestic production, reference value for imports	Yes (tracing of incurred costs within EU and abroad, importers may opt for reference values)

3.3.2.2.Detailed implementation options discussed in Chapter 5

Options for defining a **reference carbon price** (Section 5.1)

- CP.1: Uniform carbon price for the whole EU ETS trading period;
- CP.2: Carbon price determined once a year;
- CP.3: Carbon price determined once a month;
- CP.4: Daily actual allowance price;
- CP.5: Current market price.

Options for defining effective **Embedded Emissions** (EE, Section 5.2.3)

- Carbon Costs (CC) considered?
  - EE.CC.1: Carbon costs paid outside the EU are taken into account;
  - EE.CC.2: Carbon costs already paid are not taken into account.
- Value Chain (VC) considered?
  - EE.VC.1: The (upstream) value chain is taken into account;
  - EE.VC.2: Only the emissions of the final production step are used.
- Indirect Emissions (IE) taken into account?
  - EE.IE.1: Indirect emissions are taken into account.
  - EE.IE.2: Indirect emissions are not taken into account.

To each of these "EE" options, one **corresponding MRV option** can be assigned (Section 5.2.4), giving options MRV.CC.1 and 2, MRV.VC.1 and 2, and MRV.IE.1 and 2.

For the definition (determination) of **reference default values** (Section 5.2.5):

- MRV.Def.1: Default values are to be determined by data collection;
- MRV.Def.2: Default values are determined by other means, such as literature studies.

How can importers of goods **demonstrate embedded emissions**? (Section 5.2.6)

- DV.1: Only default values are used (referred to as main option 1a, but similar sub-options are possible for main options 2 and 3 as well);
- DV.2: Actual embedded emissions (based on MRV), or if unknown or not provided, the default values are used

In a compliance cycle work, **how to apply actual monitored data**? (Section 5.2.7)

- MRV.Ap.1: The emissions data apply retrospectively to imports produced during the period when the emissions have been monitored;
- MRV.Ap.2: The embedded emission values apply to imports cleared the year after acceptance of the emission report;
- MRV.Ap.3: The embedded emission values apply to all imports of the ongoing "reconciliation period".

Payment modalities for options 1 to 3 (Section 5.4):

- Pay.1: Surrender of "notional" allowances (outlined in detail in Section 5.4.2);
  - NoA.1: Non-tradable import allowances ("EUIAs");
  - NoA.2: Tradable EUIAs;
  - NoA.3: Automatic issue/surrender mechanism
- Pay.2: Surrender of EU ETS allowances (5.4.3);

- Pay.3: A tax (i.e. a payment expressible in euro, 5.4.4).

How to design a "compliance cycle":

- Cycle.1: immediate payment at the time of the import;
- Cycle.2: payment is delayed to the time of a "reconciliation" of data (annual payment);
- Cycle.3: hybrid approach with elements of Cycle.1 and Cycle.3.

How to take into account different **climate policies in third countries**?

- ClimPol.1: based on overall climate ambition of a country, as reflected in its NDC;
- ClimPol.2: based on enacted climate policies applicable to emissions from industry;
- ClimPol.3: based on the carbon price applicable to emissions from industry.

Option to apply a **differentiation between countries** (options not mutually exclusive)

- EX.1: Exemption for imports from Least Developed Countries (LDCs);
- EX.2: Exclusion of imports where the production is covered by cap-and-trade systems with a (full) link to the EU ETS

How to **adjust the EU ETS cap**, if EUAs are used for compliance in the CBAM?

- Cap.1 – "Do nothing"
- Cap.2 – "Try to get it right, simple (ex-post)"
- Cap.3 – "Try to get it right, *ex-ante*"
- Cap.4 – "MSR-based approach".

3.3.2.3.Options for a CBAM on electricity (Chapter 6):

1. **Transaction-based approaches** setting the border adjustment on the emission intensity of individual transactions;
2. **Marginal emissions-based approaches** setting the carbon border adjustment on the marginal emission intensity of the exporting system;
3. **Average-emissions based approaches** setting the carbon border adjustment on the average emission intensity of the exporting system;
4. **Joint Renewable Auctions**. An alternative approach to achieving the objectives of a CBAM, drawing on a practice already tested

Appendix 2: Stakeholder consultation results

In order to gather perspectives from a range of relevant stakeholders on the various options for CBAM, a total of 25 in-depth interviews was conducted with senior managers and associations from the basic materials sectors, manufacturers, NGOs and policymakers were conducted. The semi-structured interviews lasted one hour to 90 minutes each and focused on the Options 1b, 3, 4 and 5. The interviews were held under Chatham House Rule to allow for an open discussion, such that no names of the interviewees are provided, but findings are reported by sector.

There were two rounds of interviews. First, 17 informal interviews were conducted at an early stage of the study. In addition to gathering stakeholders' opinions, these interviews served to identify relevant points of concern and open question for further research. In a second step, eight additional interviews were conducted in order to test whether the judgements and concerns from the informal interviews were shared among a wider group of stakeholders. Consequently, where interviewees came from the basic materials sector, this second round of interviews focused more on EU sector associations, while in the first round more senior managers from individual large companies were interviewed. The second round of stakeholder interviews largely confirmed findings from the first round. The list of stakeholders consulted is presented in Table A-1.

Results and key concerns of these interviews are presented in Table A-2. Regarding Option 1 (import-only), there were major concerns regarding carbon leakage for European exporters (all materials producers), downstream manufacturers (e.g. steel), as well as resource shuffling (mostly steel and aluminium). While NGOs regarded abolishing free allowance allocation as an attractive feature of this option, some industry players saw it as an opportunity to mitigate leakage concerns in the short term if it was combined with free allocation (Option 2), albeit less of a long-term solution.

As regards Option 3 compared to Option 1, mitigating the carbon leakage risk for exporters and downstream producers was seen as an attractive feature of the option. However, strong concerns remained about resource shuffling (e.g. from steel and the chemicals sector). Administrative complexity was named as a major disadvantage in this option.

Option 4 (excise) was seen as providing an attractive investment framework into climate-neutral production processes. It was named as the preferred option by several industry and manufacturing representatives, but these interviewees also pointed out that an adequate amount of free allocation was needed to guarantee an effective carbon leakage protection. The administrative complexity was seen as manageable.

Option 5 (CAT) was seen as an attractive instrument theoretically. However, stakeholders agreed that the administrative complexity of the tracing ruled out the instrument in practice.

Table A-1: List of interviewed stakeholders.

#	Type of stakeholder	Sector (if applicable)	Name of organisation
1	Industry	Steel	ArcelorMittal
2	NGO	-	ERCST
3	Industry	Chemicals	Evonik
4	Industry	Cement	HeidelbergCement

#	Type of stakeholder	Sector (if applicable)	Name of organisation
5	Industry	Chemicals	DECHEMA
6	Industry	Cement	Peter Stemmermann (KIT/ITC)
7	NGO	-	ECF
8	NGO	-	Carbon Market Watch
9	Industry	Chemicals	Chatham House Rule
10	Industry	Metals manufacturing	WVMetalle
11	Industry	Chemicals	BASF
12	Member State Institution	-	Chatham House Rule
13	Industry	Aluminium	Thomas Mock
14	NGO	-	WWF
15	Industry	Cement	LafargeHolcim
16	Industry	Steel	ThyssenKrupp
17	Industry	Steel manufacturing	BMW
18	Industry	Cement	CEMBUREAU
19	Industry	Aluminium	European Aluminium
20	Industry	Steel	EUROFER
21	Industry	Chemicals	CEFIC
22	Member State institution	-	Federal Ministry of Economic Affairs and Energy, Germany
23	Member State institution	-	Ministry of Treasury and Ministry of Ecologic Transition, France
24	Industry	Steel manufacturing	Daimler
25	NGO	-	Ember/Sandbag

Table A-2: Summary of stakeholder consultation results.

	No. of inter-views	(1) CBAM on imports with auctioning (basic materials only)	(3) CBAM on imports and exports with auctioning (materials also in manufactured products)	(4) Excise duty with free allocation (materials also in manufactured products)	(5) Carbon added tax with CBAM (materials also in manufactured products)	Other comments
Cement	4	Surplus capacity moves pricing towards marginal costs which are higher in EU: CBAM as short-term defence; Lack of export rebate will lead to a loss of exports from European producers	Sector calls for exports to be part of the mechanism, otherwise production in Europe will be lost	Systematic approach seen as opportunity to unlock climate-neutral investment. Concern about speed of implementation and if free allocation remains sufficiently close to benchmark	In theory good carbon leakage protection, but extremely complex in construction sector. Not realistic in the short term but could be considered post-2030	Favour coexistence of CBAM and free allocation to ensure level playing field Broad sectoral scope important to avoid substitution effects
Steel	4	Primary focus on short-term survival. Surplus free allowance allocation caused by historic base line seen as rescue in current crisis, hope for additional protectionist element. Combination with full auctioning not expected. Danger of carbon leakage not solved (both for exports of basic materials, as well as imports and exports of manufactured goods if only basic materials covered), strong concerns about resource shuffling as an advantage for importers	Sector has concerns because of its high exposure to international trade; substitutes of steel need to be included (e.g. plastics, aluminium); strong resource shuffling concerns (international certification not reliable); Export rebate not seen as sufficient to avoid disruptive effects of full auctioning	Systematic approach seen as foundation for climate-neutral investment strategy (seen as most favourable option). Concern about level of continued free allowance allocation (no leakage protection without continued free allowances). Free allocation needs to be at benchmark level also for low-carbon processes. Administrative complexity is manageable.	Extremely high administrative costs due to complexity of tracing requirements. Worry about reliability of reporting for non-European countries	CBAM on imports and exports only possible if free allocation is retained ("red line")
Aluminium	2	Not seen as a viable option due to concerns about resource shuffling; high indirect carbon costs require continued compensation in case of full auctioning	Indirect carbon costs still problematic if not compensated	Sector welcomes the option, would require that also indirect emissions are covered. Simplicity of the system is attractive.	Complexity of tracing of actual emissions major disadvantage	-
Chemicals and plastic	4	Large concerns about leakage risks along value chain for most players because trade occurs mostly in later stages of the value chain	Concerns about viability given complexity of value chain. Concerns about resource shuffling	Seen as option to support sustainable business from life cycle perspective (clean processes and circularity), which is requested by many high value customers in competition with other materials; weakness that leakage protection depends on free allowance mechanism	Complexity of tracing actual emissions would require technology such as block chain. Option entails high fraud risks	Free allocation deemed necessary for transition; Resource shuffling under CBAM will remain concern as long as no international acceptance of CBAM

NGO	5	Seen as attractive tool if primary objective is moving away from free allowance allocation.	Seen as of limited relevance; worry about lack of incentives for European exporters	Seen as element for advancing investments towards climate neutrality. Could help on emission reductions from material/fertiliser efficiency and recycling. Continued free allocation might require political deal (tighter target, use of revenue for international climate action)	Important in discussions in Netherlands	
Manu-facturing	3	Fear of accumulation of burden in different countries; only basic materials seen as counteracting EU industrial strategies for manufacturing industries	Preferable to imports only CBAM, but administrative burden	Novel instrument; preferable to imports only CBAM; legally most secure variant; additional charge for EU sales seen as problematic depending on level of the charge	Not seen as viable in practice	-
Member States' policymakers	3	Differing opinions: One side: major concerns around resource shuffling and lacking coverage of exports and value chain in manufacturing industries Other side: questions future effectiveness of free allocation and sees CBAM that mirrors ETS as most effective leakage protection; little concern about resource shuffling	Differing opinions: Also problematic because of resource shuffling; administratively very challenging to track and verify imports and exports; Other side: important to rebate exports but value chain described as minor factor and not necessary for the beginning	Differing opinions: Shift of paradigm; needs long-term alignment with ETS; fiscal offset of reduced auctioning through charge; administratively comparatively easy Other side: reliance on free allocation not considered future proof and providing too little incentives for use of low-carbon materials	In theory good carbon leakage protection, but extremely complex in construction sector. Not realistic in the short term but could be considered post-2030	Need to consider trade impact of possible retaliation measures by other countries and social acceptability One side sees need to continue free allocation at least as transition

Appendix 3: Supplementing tables for Chapter 5 on the sectoral scope of the CBAM

Table A-3: ***Description of the proposed aggregated sectors which are referred to in this report. Number of installations with open registry account at the end of 2018, average emissions 2017-18, number of PRODCOM categories according to PRODCOM 2019 (unless noted differently in the footnotes). The table also shows which product benchmarks (if any) apply under the EU ETS, and whether indirect emissions play a role (indicated by the fact that there exist indirect cost compensation benchmarks for use by the environmental State Aid Guidelines.***

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2 / yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[178]	Remarks
Iron & Steel	24.10	Manufacture of basic iron and steel and of ferro-alloys	396	156,358	97	Hot metal EAF carbon steel EAF high alloy steel Iron casting (sintered ore) (Coke) Fall-backs	Basic oxygen steel EAF carbon steel EAF high alloy steel FeSi FeMn SiMn	Benchmarks in brackets may need to be considered for value chain purposes Fallback approaches for hot rolling and several other processes etc.
	24.20	Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	32	1,304	31			
	24.51	Casting of iron	28	1,705	15			
	25.50	Forging, pressing, stamping and roll-forming of metal; powder metallurgy	29	495	1*			
Refineries	19.20	Manufacture of refined petroleum products	130	132,164	10**	Refinery products (Hydrogen, synthesis gas, aromatics, high value chemicals) Fall-backs		Benchmarks mentioned in brackets are derived from the refinery BM Fallback approaches relevant e.g. for heat imports and exports.
Cement	23.51	Manufacture of cement	214	118,164	3	Grey cement clinker White cement clinker Fall-backs		Fallback approaches relevant e.g. for heat imports and exports.

178 Indirect cost compensation benchmarks are taken from the 3rd EU ETS phase, as new ones not available yet.

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2 / yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[178]	Remarks
Organic basic chemicals	20.14	Manufacture of other organic basic chemicals	331	64,877	168	Adipic acid Steam cracking Aromatics Styrene Phenol/acetone Ethylene oxide/ethylene glycols Synthesis gas Vinyl chloride monomer (Refinery Products) Fall-backs	Sector no longer eligible in fourth phase. However, the following BM were applied in the third phase: Steam cracking (HVC) Aromatics Styrene Ethylene oxide/glycols	Sector can be simplified by including only products directly covered by benchmarks (i.e. by putting the other products into the sector "other chemicals"). Otherwise very high number of very different processes and products, high number of application of fallback approaches. Refinery products benchmark mentioned, because there is often high integration of processes into refineries, and some benchmarks are derived from the refineries BM.
Fertilisers	20.15	Manufacture of fertilisers and nitrogen compounds	99	36,995	30	Ammonia Nitric acid Fall-backs	Ammonia (no longer eligible in fourth phase)	
Pulp & Paper	17.11	Manufacture of pulp	56	1,722	4	Short fibre kraft pulp		Several products outside

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2 / yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[178]	Remarks
	17.12	Manufacture of paper and paperboard	616	25,510	53	Long fibre kraft pulp Sulphite pulp Thermo-mechanical and mechanical pulp Recovered paper pulp Newsprint Uncoated fine paper Coated fine paper Tissue Testliner and fluting Uncoated carton board Coated carton board Fall-backs		the BM definition, hence fallback approaches relevant.
Lime & Plaster	23.52	Manufacture of lime and plaster	193	26,151	6	Lime Dolime Sintered Dolime (Plaster, Dried secondary gypsum, Plasterboard) Fall-backs		BM products in brackets have significantly lower specific emissions and could therefore be treated separately. Several products outside the BM definition, hence fallback approaches relevant.
Crude petroleum	06.10	Extraction of crude petroleum	132	23,492	2†	Fall-backs		
Inorganic chemicals	20.11	Manufacture of industrial gases	36	6,438	11	Carbon black	Carbon black	Very high number of very different processes and

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2 / yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[178]	Remarks
	20.13	Manufacture of other inorganic basic chemicals	113	16,045	105	Hydrogen Soda ash (Refinery Products) Fall-backs	Chlorine (not in EU ETS) Si metal hyperpure polysilicon SiC (Silicon Carbide)	products, high number of application of fallback approaches Refinery products benchmark mentioned, because the hydrogen benchmark is derived from it. Indirect emissions in some cases more important for CL than direct emissions (Chlor-Alkali).
Food & drink	10.31	Processing and preserving of potatoes	38	1,162	2*	Fall-backs		
	10.39	Other processing and preserving of fruit and vegetables	100	855	1*			
	10.41	Manufacture of oils and fats	95	2,622	30			
	10.51	Operation of dairies and cheese making	133	3,372	5*			
	10.62	Manufacture of starches and starch products	53	4,052	15			
	10.81	Manufacture of sugar	135	8,503	7			
	10.89	Manufacture of other food products n.e.c.	16	618	1*			
	11.06	Manufacture of malt	19	328	2			
Glass	23.11	Manufacture of flat glass	53	5,847	8	Float glass Bottles and jars of colourless glass Bottles and jars of		Many products outside the BM definition, hence fallback approaches relevant.
	23.13	Manufacture of hollow glass	197	10,684	18			

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2 / yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[178]	Remarks
	23.14	Manufacture of glass fibres	45	1,149	8	coloured glass Continuous filament glass fibre products Mineral wool Fall-backs		Proposal: Include "mineral wool" here instead of under "other mineral products"
	23.19	Manufacture and processing of other glass, including technical glassware	31	547	13			
Aluminium	24.42	Aluminium production	89	13,755	14	Pre-bake anode Primary Aluminium Fall-backs	Primary Aluminium Alumina (Aluminium Oxide)	Fallback approaches for forming processes, alloying,… Indirect emissions more important for CL than direct emissions.
Ceramics	23.20	Manufacture of refractory products	47	981	12	Facing bricks Pavers Roof tiles Spray dried powder Fall-backs		Many products outside the BM definition, in particular "normal building bricks", tiles, table and sanitary ware, etc., hence fallback approaches relevant.
	23.31	Manufacture of ceramic tiles and flags	303	6,829	1			
Coke	19.10	Manufacture of coke oven products	16	5,833	1	Coke Fall-backs		Coke by-products (aromatics) *not* covered by aromatics benchmark (see organic chemicals)
Polymers	20.16	Manufacture of plastics in primary forms	112	4,789	48	S-PVC	(Chlorine, Steam cracking)	Potentially very high number of very different

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2 / yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[178]	Remarks
	20.17	Manufacture of synthetic rubber in primary forms	9	866	2	E-PVC (Steam cracking, Vinyl chloride monomer, Adipic acid, Synthesis gas, Refinery Products) Fall-backs		processes and products, high number of applications of fallback approaches. Benchmarks in brackets added for the production of the monomers (i.e. pre-cursors of the polymers), as those are the emission-intensive processes, while the polymers are the trade-intensive ones. Refinery products benchmark mentioned, because there is often high integration of processes into refineries.
Non-ferrous metals (except Al)	24.43	Lead, zinc and tin production	20	1,903	11	Fall-backs	Zinc electrolysis	Indirect emissions often more important for CL than direct emissions.
	24.44	Copper production	21	2,040	13			
	24.45	Other non-ferrous metal production	–[††]	190	42			
Other mineral products	23.99	Manufacture of other non-metallic mineral products n.e.c.	212	3,691	15	Fall-backs		
Other chemicals	20.12	Manufacture of dyes and pigments	22	1,779	31	Fall-backs		
	20.30	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	18	377	2			
	20.60	Manufacture of man-made fibres	19	1,101	24			
Mining	07.10	Mining of iron ores	–[††]	682	2	Sintered ore		

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2 / yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[178]	Remarks
	08.12	Operation of gravel and sand pits; mining of clays and kaolin	7	156	1*	Fall-backs		
	08.91	Mining of chemical and fertiliser minerals	–††	52	4			
	08.99	Other mining and quarrying n.e.c.	16	1,703	7			
Wood-based panels	16.21	Manufacture of veneer sheets and wood-based panels	108	1,919	18	Fall-backs		
Textiles	13.10	Preparation and spinning of textile fibres	–††	28	42			
	13.95	Manufacture of non-wovens and articles made from non-wovens, except apparel	–††	68	5			
Other installations			18	1,020				

† Number of CN codes given, as there is no PRODCOM code

†† For reasons of confidentiality, these installations have been grouped under "other installations".

* In case of sectors indicated by an asterisk, only a limited number of PRODCOM sectors are on the carbon leakage list (CLL)

** Number of PRODCOM 2004 codes (no codes in current PRODCOM system); There are 46 corresponding CN codes.

Table A-4: ***Example of how different materials and products can be identified by the HS codes (compatible to CN codes used in European customs[179]) of all included product categories***

CBAM Product name	HS code	Description of the HS code	Include in CBAM?
Pig iron	720110	Pig iron, non-alloy, <0.5% phosphorus	No
	720120	Pig iron, non-alloy, >0.5% phosphorus	No
	720130	Alloy pig iron, in primary forms	No
Ferro-Alloys	720211	Ferro-manganese, >2% carbon	No
	720219	Ferro-manganese, <2% carbon	No
	720221	Ferro-silicon, >55% silicon	No
	720229	Ferro-silicon, <55% silicon	No
	720230	Ferro-silico-manganese	No
	720241	Ferro-chromium, >4% carbon	No
	720249	Ferro-chromium, <4% carbon	No
	720250	Ferro-silico-chromium	No
	720260	Ferro-nickel	No
	720270	Ferro-molybdenum	No
	720280	Ferro-tungsten and ferro-silico-tungsten	No
	720291	Ferro-titanium and ferro-silico-titanium	No
	720292	Ferro-vanadium	No
	720293	Ferro-niobium	No
	720299	Ferro-alloys, nes	No
DRI (Direct reduced iron)	720310	Ferrous products from direct reduction of iron ore	No
	720390	Spongy iron lumps, pellets, etc. > 99.94% pure	No
Iron and steel Scrap	720410	Waste or scrap, of cast iron	No
	720421	Waste or scrap, of stainless steel	No
	720429	Waste or scrap, of alloy steel, other than stainless	No
	720430	Waste or scrap, of tinned iron or steel	No
	720441	Waste from the mechanical working of iron or steel ne	No
	720449	Ferrous waste or scrap, nes	No
	720450	Remelting scrap ingots, of iron or steel	No
Iron & steel primary forms	720510	Granules of pig iron or spiegeleisen	Yes
	720521	Powders, alloy steel	Yes
	720529	Powders, iron or steel, other than alloy	Yes
	720610	Iron or non-alloy steel in ingots, <99.94% iron	Yes
	720690	Iron or non-alloy steel, primary nes, <99.94% iron	Yes
	720711	Rectangular iron or non-alloy steel bars, <.25%C, width< twice thicknes	Yes
	720712	Semi-finished bars, iron or non-alloy steel <0.25%C, rectangular, nes	Yes
	720719	Semi-finished product, iron or non-alloy steel <0.25%C, nes	Yes
	720720	Semi-finished product, iron or non-alloy steel >0.25%C	Yes
Hot-rolled & further	720821	Hot-rolled iron or non-alloy steel, coil,width >600mm, t >10mm, nes	Yes

[179] The 6 digits of the HS codes are identical to the first digits of the more differentiated 8-digits CN codes.

CBAM Product name	HS code	Description of the HS code	Include in CBAM?
steps	720822	Hot-rolled iron or non-alloy steel, coil,width >600mm, t 4.75-10mm, nes	Yes
	720823	Hot-rolled iron or non-alloy steel, coil,width >600mm, t 3-4.75mm, nes	Yes
	720824	Hot-rolled iron or non-alloy steel, coil,width >600mm, t <3mm thick, ne	Yes
	720842	Hot-rolled iron or non-alloy steel, flat,width >600mm, t >10mm, nes	Yes
	720843	Hot-rolled iron or non-alloy steel, flat,width >600mm, t 4.75-10mm, nes	Yes
	720844	Hot-rolled iron or non-alloy steel, flat,width >600mm, t 3.0-4.75mm, ne	Yes
	720845	Hot-rolled iron or non-alloy steel, flat,width >600mm, t <3mm, nes	Yes
	720890	Hot-rolled iron or non-alloy steel, width >600mm, nes	Yes
	720921	Cold-rolled iron or non-alloy steel, coil, width >600mm, t >3mm, nes	Yes
	720922	Cold-rolled iron or non-alloy steel, coil, width >600mm, t 1-3mm, nes	Yes
	720923	Cold-rolled iron or non-alloy steel, coil, width >600mm, t 0.5-1mm, nes	Yes
	720924	Cold-rolled iron or non-alloy steel, coil, width >600mm, t <0.5mm, nes	Yes
	720941	Cold-rolled iron or non-alloy steel, flat, width >600mm, t >3mm, nes	Yes
	720942	Cold-rolled iron or non-alloy steel, flat, width >600mm, t 1-3mm, nes	Yes
	720943	Cold-rolled iron or non-alloy steel, flat, width >600mm, t 0.5-1mm, nes	Yes
	720944	Cold-rolled iron or non-alloy steel, flat, width >600mm, t <0.5mm, nes	Yes
	720990	Cold-rolled iron or non-alloy steel, flat, width >600mm, nes	Yes
	721121	Hot box rolled iron or non-alloy steel, flat, w 150-600mm,t >4mm, uncla	Yes
	721122	Hot-rolled iron or non-alloy steel, width <600mm, t >4.75mm, unclad nes	Yes
	721129	Hot-rolled iron or non-alloy steel, width <600mm unclad, nes	Yes
	721141	Flat rolled iron or non-alloy steel, width <600mm, unclad, <0.25% C, ne	Yes
	721149	Flat rolled iron or non-alloy steel, width <600mm, unclad, nes	Yes
	721190	Flat rolled iron or non-alloy steel, width <600mm, unclad, nes	Yes
	721210	Flat rolled iron or non-alloy steel, width <600mm, plated with tin	Yes
	721229	Flat rolled steel, <600mm, electro-plated zinc, nes	Yes
	721260	Flat rolled iron or non-alloy steel, width <600mm, clad	Yes
	721310	Hot-rolled bar/rod grooved iron or non-alloy steel in irregular coils	Yes
	721320	Hot-rolled bar/rod, irregular coils,free cutting stee	Yes
	721331	Hot-rolled bar/rod, iron or non-alloy steel, coiled width <14mm, C<.25%	Yes
	721339	Hot-rolled bar/rod, iron or non-alloy steel, coiled, C<.25%, nes	Yes
Coated hot-rolled & further steps	721011	Flat rolled iron or non-alloy steel, coated with tin, w >600mm, t >0.5m	Tbd.
	721012	Flat rolled iron or non-alloy steel, coated with tin, w >600mm, t <0.5m	Tbd.
	721020	Flat rolled iron or non-alloy steel, coated with lead, width >600mm	Tbd.
	721039	Flat rolled iron or non-alloy steel, electro plate/zinc,w >600mm, nes	Tbd.
	721041	Flat rolled iron or non-alloy steel, coat/zinc, corrugated, w >600m, ne	Tbd.
	721049	Flat rolled iron or non-alloy steel, coated with zinc, width >600mm, ne	Tbd.

CBAM Product name	HS code	Description of the HS code	Include in CBAM?
	721050	Flat rolled iron or non-alloy steel, coated chromium/oxides, w> 600 mm	Tbd.
	721060	Flat rolled iron or non-alloy steel, coated with aluminium, width>600mm	Tbd.
	721070	Flat rolled iron or non-alloy steel, painted/plastic coated,width>600mm	Tbd.
	721090	Flat rolled iron or non-alloy steel, clad/plated/coated, w >600mm, nes	Tbd.
	721230	Flat rolled iron or non-alloy steel, <600mm, coated with zinc, nes	Tbd.
	721240	Flat rolled iron or non-alloy steel, <600mm, painted/plastic coated	Tbd.
	721250	Flat rolled iron or non-alloy steel, <600mm, plated/coated, nes	Tbd.
Forged, extruded, wire etc.	721410	Bar/rod, iron or non-alloy steel, forged	No
	721420	Bar/rod, iron or non-alloy steel, indented or twisted, nes	No
	721430	Bar/rod, iron or non-alloy steel, of free cutting steel, nes	No
	721440	Bar/rod, iron or non-alloy steel, hot formed <0.25%C, nes	No
	721510	Bar/rod, cold formed/finished free cutting steel	No
	721540	Bar/rod, iron or non-alloy steel, cold formed/finished, >0.6%C	No
	721590	Bar/rod, iron or non-alloy steel, nes	No
	721610	Sections, U/I/H, iron or non-alloy steel, nfw than hot formed <80mm	No
	721621	Sections, L, iron or non-alloy steel, nfw hot-roll/drawn/extruded < 80m	No
	721622	Sections, T, iron or non-alloy steel, nfw hot-roll/drawn/extruded < 80m	No
	721631	Sections, U, iron or non-alloy steel, nfw hot-roll/drawn/extruded > 80m	No
	721632	Sections, I, iron or non-alloy steel, nfw hot-roll/drawn/extruded > 80m	No
	721633	Sections, H, iron or non-alloy steel, nfw hot-roll/drawn/extruded > 80m	No
	721640	Sections,L/T,iron or non-alloy steel, nfw hot-roll/drawn/extruded > 80m	No
	721650	Sections, nes, iron or non-alloy steel, nfw hot-roll/drawn/extruded	No
	721660	Sections, nes, iron or non-alloy steel, nfw than cold formed/finished	No
	721690	Angles/shapes/sections, iron or non-alloy steel, nes	No
	721711	Wire, iron or non-alloy steel, not plated or coated, <0.25%C	No
	721712	Wire, iron or non-alloy steel, plated or coated with zinc <0.25%C	No
	721713	Wire, iron or non-alloy steel, of base metal plated/coated nes, <0.25%C	No
	721739	Wire, iron or non-alloy steel, more than 0.6% carbon, nes	No
Stainless steel	721810	Ingots and other primary forms, stainless steel	No
	721890	Semi-finished products, stainless steel	No
	721911	Hot-rolled stainless steel coil, w >600mm, t >10mm	No
	721912	Hot-rolled stainless steel coil, w >600mm, t 4.75-10m	No
	721913	Hot-rolled stainless steel coil, w >600mm, t 3-4.75mm	No
	721914	Hot-rolled stainless steel coil, w >600mm, t <3mm	No
	721921	Hot-rolled stainless steel flat, w >600mm, t >10mm	No
	721922	Hot-rolled stainless steel flat, w >600mm, t 4.75-10m	No
	721923	Hot-rolled stainless steel flat, w >600mm, t 3-4.75mm	No
	721924	Hot-rolled stainless steel flat, w >600mm, t <3mm	No
	721931	Cold-rolled stainless steel, w >600mm, t >4.75mm	No
	721932	Cold-rolled stainless steel, w >600mm, t 3.0-4.75mm	No

CBAM Product name	HS code	Description of the HS code	Include in CBAM?
	721933	Cold-rolled stainless steel, w >600mm, t 1.0-3.0 mm	No
	721934	Cold-rolled stainless steel, w >600mm, t 0.5-1.0 mm	No
	721935	Cold-rolled stainless steel, w >600mm, t /0.5 mm	No
	721990	Rolled stainless steel sheet, width > 600mm, nes	No
	722011	Hot-rolled stainless steel sheet, w <600mm, t >4.75 m	No
	722012	Hot-rolled stainless steel sheet, w <600mm, t <4.75 m	No
	722020	Stainless steel sheet, w <600mm, cold-rolled/reduced	No
	722090	Rolled stainless steel sheet, width < 600mm, nes	No
	722100	Bar or rod, stainless steel, hot-rolled, coiled	No
	722210	Stainless steel bar nfw than hot-rolled/drawn/extrude	No
	722220	Stainless steel bar nfw than cold formed/cold finishe	No
	722230	Stainless steel bar or rod nes	No
	722240	Angles, shapes and sections, stainless steel	No
	722300	Wire of stainless steel	No
Other alloyed steel	722410	Ingots, primary forms of alloy steel, except stainles	No
	722490	Semi-finished products of alloy steel except stainles	No
	722510	Flat rolled silicon-electrical steel, width >600mm	No
	722530	Hot-rolled alloy steel, coils width >600mm, nes	No
	722540	Hot-rolled alloy steel, not in coil width >600mm, nes	No
	722550	Cold-rolled alloy steel, width >600mm, nes	No
	722590	Flat rolled alloy steel, width >600mm, nes	No
	722610	Flat rolled silicon-electrical steel, <600mm wide	No
	722620	Flat rolled high speed steel <600mm wide	No
	722691	Hot-rolled alloy steel nes nfw, <600mm wide	No
	722692	Cold-rolled alloy steel nes nfw, <600mm wide	No
	722699	Flat rolled alloy steel, <600mm wide, nes	No
	722710	Bar/rod, of high speed steel, irregular coils	No
	722720	Bar/rod, of silico-manganese steel, irregular coils	No
	722790	Bar/rod, alloy steel nes, irregularly wound coils	No
	722810	Bar/rod of high speed steel not in coils	No
	722820	Bar/rod of silico-manganese steel not in coils	No
	722830	Bar/rod, alloy steel nes,nfw hot-rolled/drawn/extrude	No
	722840	Bar/rod nes, alloy steel nes, nfw forged	No
	722850	Bar/rod nes, alloy steel nes, nfw cold formed/finishe	No
	722860	Bar/rod, alloy steel nes	No
	722870	Angles, shapes and sections, alloy steel, nes	No
	722880	Hollow drill bars and rods of alloy/non-alloy steel	No
	722920	Wire of silico-manganese steel	No
	722990	Wire of alloy steel nes	No

Appendix 4: Electricity CBAM – insights from the New York State proposal

The impact on dispatching can either be achieved by adding an import charge to electricity imports, or by deducting from internal prices the marginal emissions costs of the importing market for the purpose of dispatching decisions. The first option sets correct price signals and avoids that high-emitting coal plant imports displace cleaner alternatives when CO_2 prices are high enough for a fuel switch to have occurred in European power markets. The second option is easier to implement, as less information regarding neighbouring countries is necessary. Producers are still partly protected as the cross-border dispatching ignores the carbon price signal.

An approach that combines (sub-)hourly marginal emissions with deduction of carbon prices for the purpose of cross-border dispatching is currently under consideration for implementation in the US State of New York. This would impose the net carbon price differential to electricity imported into the territory of the local transmission system operator based on the carbon intensity of the marginal unit of power production at the time of import. This concrete policy proposal – which also applies to electricity exports – is outlined below.

In June 2019, New York enacted the Climate Leadership and Community Protection Act (CLCPA), which calls for the state to achieve 70% renewable electricity by 2030, 100% emission-free electricity by 2040, and economy-wide carbon neutrality by the middle of the century. In anticipation of this ambitious decarbonisation mandate, the New York Independent System Operator (NY ISO) initiated a process to consider policy options to better align the wholesale electricity markets it operates, including carbon pricing as a way of harnessing cost-effective abatement options and sending an effective price signal throughout the sector. Studies have indicated that substantial savings would be possible from deploying carbon pricing in achievement of the ambitious mitigation targets set out in the legislation (ACE NY, 2019; Tierney and Hibbard, 2019).

In April 2018, an Integrating Public Policy Task Force (IPPTF)[180] was created as a multi-stakeholder forum to explore concepts and proposals for incorporating the social cost of carbon emissions in wholesale energy markets. Building on prior proposals and stakeholder feedback (NY ISO, 2018a), NY ISO released a carbon pricing proposal on 7th December 2018 (NY ISO, 2018b). This proposal would require suppliers of carbon emitting energy suppliers to pay a charge – based on a Gross Social Cost of Carbon (SCC) estimate set by the New York Public Service Commission (PSC) – for carbon emissions as part of the settlement process. Suppliers would embed these additional carbon charges in their energy offers (the "carbon adder") and thus incorporate the carbon price into the unit commitment, dispatch, and price formation in the wholesale market. Resources subject to a carbon price under the Regional Greenhouse Gas Initiative (RGGI) would have the most recently posted daily carbon price under that emissions trading system credited towards the social cost of carbon.

In its proposal, NY ISO conceded that a carbon charge imposed only on generation within New York ("internal resources") could render these less competitive compared to resources in neighbouring states. This could result in an increase of imports – potentially straining transmission limits – and reducing exports. Also, it acknowledged that production could shift to resources outside of New York that would not otherwise generate and would likely be more carbon-intensive.

180 IPPTF was created as a forum for a NYISO and New York State joint staff team comprised of NYISO, New York Department of Public Service (NY DPS), and New York State Energy Research and Development Authority (NYSERDA) staff to solicit stakeholder feedback.

To counteract such distortions, the NY ISO proposed that the carbon charge of the marginal power plant in NYISO would be considered, such that they compete with internal resources on a level playing field. Imports would earn the Locational Based Marginal Price (LBMP) based on the system marginal costs without the carbon effect, or impact, at the relevant border; similarly, exports would buy energy at the LBMP without the carbon effect, or impact.

The LBMP would apply to all external transactions, with no unit-specific or portfolio-specific exceptions for existing or new clean energy resources. Carbon charges (and credits) would only apply to transacted MWhs that flow in real-time because that provides the appropriate signal when comparing imports and exports to actual internal generation. Import and export schedules would continue to be determined as they are today in NYISO, via the system optimisation software, based on import and export bids. Wheel-through transactions, finally, would pass through without being subjected to carbon charges other than the difference between entry and exit points, as they are already assessed congestion and marginal losses today. They would face the equivalent of an import transaction at the entry point plus an export transaction at the exit point.

One drawback of this approach, that treats imports from all sources equally rather than distinguishing by the marginal emissions consequences of the transaction, is that it does not incentivise cost-effective carbon abatement outside of New York. However, a study has indicated that there are limited opportunities to achieve additional carbon abatement by incentivising abatement outside of New York (Newell, 2018). It finds that among neighbouring states, there is no evidence of underutilised low-emitting resources whose output could increase if only offered a higher price. The only opportunity found to reduce emissions in the operating timeframe would likely be reductions in coal-based imports from the Pennsylvania-New Jersey-Maryland Interconnection (PJM).

Currently, the NY ISO carbon pricing proposal is still under negotiation with the New York State Government, which has yet to approve it. Also, in order to implement the carbon pricing proposal, NY ISO will need to file for changes under Section 205 of the Federal Power Act, which requires a stakeholder process where a supermajority of 58% or more would have to approve the plan (Morehouse, 2020).

While the NY ISO carbon pricing proposal contains one of the more elaborate proposals for a carbon border adjustment for electricity released to date, it is again important to note that the geographic, economic and regulatory contexts differ considerably from those in the EU. Several points need to be considered: it relies heavily on a central clearing algorithm, that identifies the marginal power plant within NYISO, and levels the playing field, by subtracting the carbon costs for the purpose of imports and exports, rather than imposing a carbon charge on imports. Thus, no incentives for the dispatch of low-carbon power plants are given in the neighboring market. This has the practical benefit of not needing any information regarding the bordering market.

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