EUROPEAN
COMMISSION

Brussels, 14.7.2021
SWD(2021) 643 final

PART 2/2

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT REPORT

Accompanying the document

Proposal for a regulation of the European Parliament and of the Council

establishing a carbon border adjustment mechanism

{COM(2021) 564 final} - {SWD(2021) 644 final} - {SWD(2021) 647 final} -
{SEC(2021) 564 final}

Table of contents

ANNEX 1: PROCEDURAL INFORMATION 1

ANNEX 2: STAKEHOLDER CONSULTATION 1

ANNEX 3: WHO IS AFFECTED AND HOW? 1

ANNEX 4: ANALYTICAL METHODS 1

ANNEX 5: DEFINITIONS 1

ANNEX 6: COMPLIANCE COSTS FOR BUSINESSES 1

ANNEX 7: SELECTION OF SECTORS 1

ANNEX 8: CASE OF ELECTRICITY – IMPACTS 1

ANNEX 9: ENERGY SYSTEM IMPACT OF AN IMPORT CBAM ON MATERIALS (IN THE FORM OF A NOTIONAL ETS BASED ON EXPORTING COUNTRIES' AVERAGE) 1

ANNEX 10: STATISTICAL ANNEX (TABLES AND REFERENCES TO THE MAIN TEXT) 1

ANNEX 11: EVIDENCE OF CARBON LEAKAGE 1

Glossary

Term or acronym	*Meaning or definition*
BM	Product Benchmark
BREF	EU Best Available Techniques Reference Documents
CAT	Carbon Added Tax
CBAM	Carbon Border Adjustment Mechanism
CDM	Clean Development Mechanism
CES	Constant Elasticity of Substitution
CHP	Combined Heat and Power
CIT	Corporate Income Tax
CL	Carbon Leakage
CLL	Carbon Leakage List
CN	Combined Nomenclature
CWT	Complexity Weighted Tonnes
CO_2	Carbon Dioxide
CTP	Climate Target Plan
DRI	Direct Reduced Iron
DSGE	Dynamic Stochastic General Equilibrium
EITE	Energy Intensive and Trade Exposed
ETS	Emissions Trading System
FAR	Free Allocation Rules
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GVA	Gross Value Added
HS	Harmonized System
JRC-GEM-E3	General Equilibrium Model for Economy-Energy-Environment
MRV	Monitoring, Reporting and Verification

NACE	Statistical Classification of Economic Activities in the European Community
NGO	Non-Governmental Organisation
NPK fertilisers	Nitrogen-Phosphorus-Potassium fertilisers
SMEs	Small and Medium-sized Enterprises
VAT	Value Added Tax
VCM	Vinyl Chloride Monomer
WTO	World Trade Organisation

ANNEX 1: PROCEDURAL INFORMATION

1. Lead DG, Decide Planning/CWP references

The lead DG is the Directorate-General for Taxation and Customs Union. The Decide reference of this initiative is PLAN/2020/6513.

The Commission Work Programme for 2021 provides, under heading A European Green Deal, the policy objective of 'Fit for 55 Package', the initiative for a Carbon Border Adjustment Mechanism (CBAM) and a proposal for CBAM as own resource (legislative, incl. impact assessment, planned for Q2 2021).

2. Organisation and timing

The Inter-service Steering Group was set up by the Secretariat-General to assist in the preparation of the initiative. The representatives of the following Directorates General participated in the ISSG work: Legal Service, CLIMA, TRADE, JRC, COMP, GROW, ECFIN, ENER, EEAS, INTPA, NEAR, MOVE, BUDG, ENV, AGRI, JUST, RTD, REA, MARE.

A total of five Inter-Service Steering Group meeting took place, with the last being on 16 March 2021.

It should be noted that in addition to the Inter-Service Steering Group, DG TAXUD held seven meetings to discuss the design and legal issues of the mechanism with representatives from the following Directorates General: Legal Service, CLIMA, TRADE, ENER, BUDG, NEAR. The last meeting of the group took place on 11 January 2021.

3. Consultation of the RSB

On 17 March 2021, DG TAXUD submitted the draft Impact Assessment to the Regulatory Scrutiny Board and the Board meeting took place on 21 April 2021. The opinion of the Board, as issued on 23 April 2021, was positive with reservations.

The Board's recommendations have been addressed as presented below.

1) The report should be self-standing. It should describe the existing measures to prevent carbon leakage and better identify their weaknesses.

The recommendation was addressed by expanding the discussion under the problem definition of the impact assessment (Section 2). An addition subsection was introduced (Section 2.2 'How is the problem currently being addressed?') outlining how the risk of carbon leakage has been identified from the beginning of the EU ETS and what have been the two mechanisms, employed under the existing system to address it (i.e. free allocation of ETS allowances and the possibility for Member States to give state aid to electro-intensive undertakings active in a sector exposed to international trade). The discussion on the evidence on the risk of carbon leakage as identified in the literature was also improved and expanded drawing from the analysis previously detailed under Annex 11.

2) The report should strengthen the discussion on the coherence with the new ETS proposal. It should explain to what extent the ETS revision depends on the CBAM *initiative. The report should justify why it deviates from the ETS on some aspects, such as sectoral coverage and the inclusion of transport emissions. It should better explain why it proposes a parallel system with CBAM certificates to match the carbon content of imports, instead of ETS allowances. The report should be more explicit on the envisaged timeframe for the gradual introduction of CBAM and its coherence with the revision of the ETS.*

The recommendation was addressed by expanding the analysis under Section 2.4 'How will the problem evolve?'. The discussion now provides a more detailed account of the fact that the CBAM would be complementary to the EU ETS, with a view to addressing the risk of carbon leakage and reinforcing the EU ETS itself. It proceeds by explaining the interdependence of CBAM proposal and the proposal of EU ETS revision in the context of problem evolution. In this context, the report further explains, under Section 5.2.1.1 'Scope of emissions', the reasons for not including transport emissions at this stage. Specifically at this stage the details of the extension of the ETS to transport are not fully known and will in any case depend on the outcome of the legislative process. It would be more prudent to schedule the inclusion of transport emission to take place when the scope of CBAM is next revised. On sectoral coverage the report is clear in that the choice of CBAM's coverage is framed by the sectors and emissions covered by the EU ETS. Moreover, the discussion in Section 5.2.3 'Option 2: Import certificates for basic materials based on EU average' has been expanded to provide more insight on the methodological choices regarding the design of CBAM certificates. Finally, the discussion under Section 8 'Preferred option' now discusses the main issues related to the envisaged timeframe of the measure.

3) The report should better present and analyse the costs and benefits of different administrative options, in particular centralised versus decentralised implementation, to clearly inform the political choices. It should discuss the risks for a timely implementation, in particular linked to the development of IT systems and the potential set-up of a central administrative CBAM body.

The recommendation was addressed by expanding the analysis under Section 5.2.1 'Design elements common to all options' through the introduction of a new section on 5.2.1.9 'Elements related to administrative design'. The discussion now clarifies that there are essentially two main options in the institutional design of CBAM -a centralised system based on a Central CBAM authority at EU level and a decentralised system resting on national authorities of Member States. The main characteristics, as well as the benefits and costs of each are also discussed. Section 5.2.1.9 also provides a provisional estimate of the costs and staffing needs related to the administrative set up for the measure. Finally, the discussion under Section 8 'Preferred option' discuss issues related to timely implementation and the potential simplifications that may be necessary to ensure CBAM is operational from 2023.

4) As CBAM is an alternative to free allowances, the initiative should be mainly compared with the scenario with free allowances, and not with the counterfactual with full auctioning.

The recommendation was addressed by comparing all the CBAM options to the MIX scenario with free allowances. As indicated in the Board's detailed technical comments the full auctioning variant was maintained as an additional reference point to disentangle the effect of removing free allowances from the specific effects of introducing CBAM.

5) The impact analysis should better highlight the effects of the introduction of CBAM on the competitiveness of EU exporters on third-country markets. It should better integrate the risks and consequences of resource shuffling and of carbon leakage down the value chain.

The recommendation was addressed by expanding the analysis in different parts of the impact assessment report. Specifically, section 6.4.3 'Trade impacts' provides a more detailed clarification on the effects of CBAM on EU export competitiveness, while the analysis in the said section has been expanded to include also the views of stakeholders on this matter as recorded in the Commission's open public consultation. The report has also been expanded to integrate more clearly and concretely the risks and consequences of resource shuffling and carbon leakage down the value chain. Section 5.2.1.10 'Resource shuffling' now provides a more detailed analysis of the drivers and implications of resource shuffling. References on the limitations posed by the problem are also included in the impacts section. Nevertheless, the report also recognise that resource shuffling is an unescapable fact, difficult to quantify ex ante. Equally, the report seeks to balance the fact that even in the presence of resource shuffling, the fact that those third countries have to make an effort to produce low carbon-intensive products for the EU market will be positive from a climate perspective. Finally, section 6.2.2 'Preventing Carbon leakage' provides a more insight into the impacts on the value chain and the drivers of this impact (complexity of manufacturing process downstream and corresponding value added in later stages).

6) While global emissions and engaging with third countries are part of the (specific) objectives, the relation with third countries should receive more attention. The report should explain how the CBAM initiative is consistent with the Paris Agreement, and its parties setting their own ambition levels.

The recommendation was addressed by expanding the analysis under Section 2.1 'What is the problem?' and the inclusion of a new section (2.1.1) on 'CBAM in the context of the Paris Agreement'.

7) The report should systematically take into account the comments made by the different stakeholder groups throughout the report. In particular, it should be transparent on their positions on the different options and confront any concerns with the findings of the analysis.

The recommendation was addressed by including references and further insight from the feedback obtained from different stakeholder on the Open Public Consultation. Views of stakeholders on the different policy options, as well as on anticipated impacts on business and consumers have been integrated in differentiated assessments in the body of the report. The analysis now clarifies that by introducing a CBAM, the EU will ensure that goods imported into the EU follow the same rules as the goods produced in the EU without interfering with policy choices in third countries. In order to respect the Paris Agreement and the principle of nationally determined contributions (NDC) therein as well as the principle of Common but Differentiated responsibility, the CBAM would be designed in such manner that it does not directly depend on the overall level of ambitions of a country or on the policy choices made by a country.

8) The methodological section (in the annex), including methods, key assumptions, and baseline, should be harmonised as much as possible across all 'Fit for 55' initiatives. Key methodological elements and assumptions should be included concisely in the main *report under the baseline section and the introduction to the options. The report should refer explicitly to uncertainties linked to the modelling. Where relevant, the methodological presentation should be adapted to this specific initiative.*

The recommendation was addressed by further clarifying the methods, key assumptions, and baseline ensuing harmonised approach and presentation to other 'Fit for 55' initiatives. Key methodological elements and assumptions presented in the main report under the baseline section and the introduction to the options have been further strengthened and clarified.

4. Evidence, sources and quality

The evidence for the impact assessment report was gathered through various activities and from different sources:

- Studies on Carbon Leakage:
  - 2030 Revised climate ambition impact assessment
  - Carbon Leakage in the Emissions Trading System (ETS) Phase 3 and 4
  - Alternatives to address carbon leakage – DG CLIMA
- Studies on Carbon Border Adjustment:
  - Design and effects
  - Modelling – JRC and DG ECFIN
  - World Trade Organisation (WTO) – DG TRADE
  - OPC results analysis
  - Effect of a CBAM on energy markets – DG ENER
- Feedback on the Inception Impact Assessment
- Desk research

ANNEX 2: STAKEHOLDER CONSULTATION

1. Introduction

For the preparation of this initiative, the Commission designed a stakeholder's consultation strategy, which is summarized in this synopsis report. The aim of the synopsis report is to present the outcome of the consultation activities and to show how the input has been taken into account.

The consultation strategy encompasses both public and targeted consultations. Further details are given in Table 2-1.

Table 2-1: Overview of consultation activities

Methods of consultation		Stakeholder group	Consultation period	Objective/Scope of consultation
Inception Impact Assessment (feedback mechanism)		Academic/research institutions Business association Company EU citizen Non-EU citizen Non-Governmental Organisations (NGOs) Trade Union Public Authorities	4 March – 1 April 2020	Collect feedback on the inception impact assessment outlining the initial considerations of the project.
Targeted Consultation	By External Contractor	Business Association Company Public authorities NGOs	September – December 2020	Gather perspectives on the various options for CBAM. Identify relevant points of concern and open questions for further research.
Targeted Consultation	Bilateral Stakeholder's meetings	Business Association Company Public authorities	2020 – 2021	Discuss issues and policy options with shareholders to ascertain views and possible impacts on specific sectors. Share knowledge and experience.
Public Consultation		Academic/research institutions Business association Company EU citizen Non-EU citizen NGOs Trade union Public Authorities	22 July – 28 October 2020	Ascertain the views of a broad range of stakeholders mainly on the justifications, objectives, potential design and scope as well as impacts of the initiative.

The main objectives of the different consultation streams are:

- Provide stakeholders and the wider public with the opportunity to express their views on all relevant elements.
- Gather specialised input to support the analysis of the impact of the initiative.

- Contribute to design the technical aspects of the future initiative.
- Satisfy transparency principles and help to define priorities for the future initiative.

As reflected above by the different methods of consultation used and stakeholders groups reached, the stakeholder consultation strategy has formed an integral part of the policy development process.

2. Consultation participation

1. Feedback on the inception impact assessment

The consultation period through this feedback mechanism took place between 4 March and 1 April 2020 via the Commission website. The period started when the inception impact assessment was published outlining the initial thinking and policy options of the project. 219 responses were submitted during this consultation period broken down into: approximately 150 responses by trade federations, business associations and individual businesses, 20 NGOs, 20 citizens and the remaining from think tanks, academic/research institutions, trade unions and public authorities. The majority of responses came from the EU, with 24 from third countries.

2. Targeted consultation

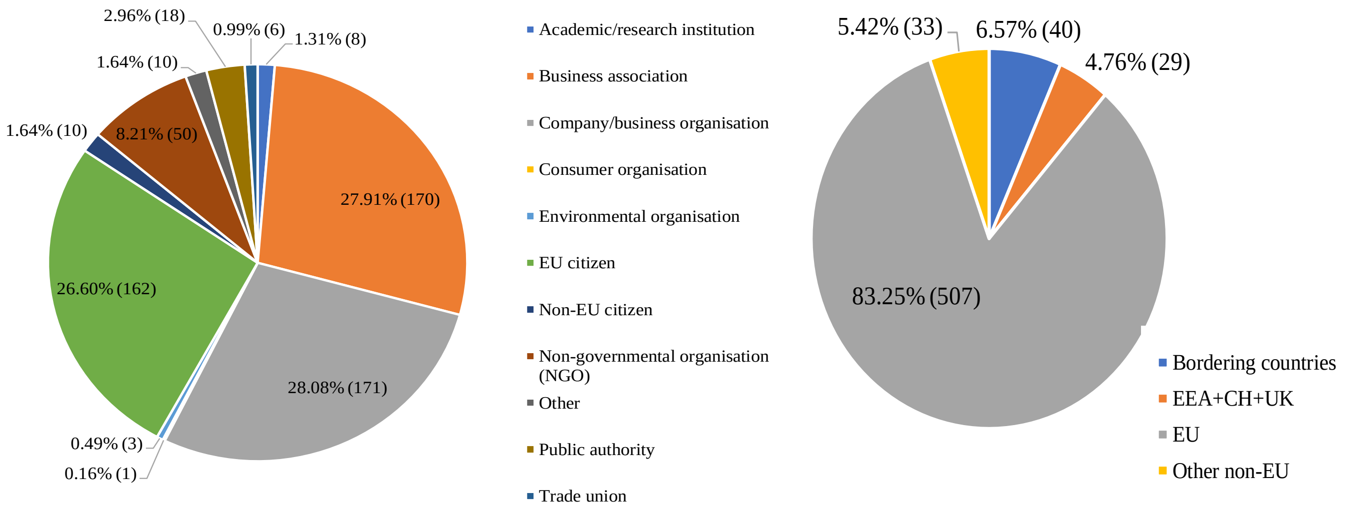
The external contractor conducted a total of 25 in-depth interviews with senior managers and associations from the basic materials sectors, manufacturers, NGOs and policymakers. There were two rounds of interviews. First, 17 informal interviews were conducted at an early stage of the study. In addition 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. 17 stakeholders came from industry, 5 from NGOs and 3 from Member State institutions.

3. Public Consultation

The public consultation was placed on the Commission website, and remained open for fourteen weeks from 22 July 2020 to 28 October 2020 in line with the Better Regulations Guidelines. The consultation questionnaire consisted of 43 questions: 38 closed-ended questions and 5 open-ended questions and aimed to gather opinions from citizens and organisations on the justifications, objectives, potential design and scope as well as impacts of the initiative. Respondents were also allowed to upload position papers.

A total of 615 respondents participated in the public consultation. Of these, 6 responses were duplicates, leading to 609 valid contributions. Figure 2-1 presents the type and countries of the stakeholders. From the point of view of the size of the organisations involved, 120 are micro (1 to 9 employees), 108 small (10 to 49 employees), 53 medium (50 to 249 employees) and 156 large (more than 250 employees).

Figure 2-1: Types and countries of respondents



Source: Public consultation questionnaire responses

A total of 228 position papers were submitted by the respondents. Overall, 121 position papers were selected for the final analysis. These were selected based on 3 selection criteria, namely: sector, respondent type and country (with balanced representation between member States and non-EU countries). 115 of these papers were selected from the survey consultation. In addition, 6 papers were selected from the Inception Impact Assessment consultation to cover respondent categories that were not sufficiently covered in the survey consultation.

It is also worth remarking that two campaigns were identified. More specifically Campaign A includes 23 responses by stakeholders based either in Germany or Austria and belonging to EU citizens or NGOs stakeholders. They are in favour of a CBAM to address carbon leakage while fighting against climate change and they show preference for the excise duty and import tax options. Campaign B comprises 22 responses by stakeholders (companies, business associations but also 1 Public authority and 1 NGO) with some linkages with the Russian steel value chain. Their answers are identical and they argue that a CBAM would impose unnecessary burdens on the EU industry, they emphasise that current measures (e.g. EU ETS and EU state aid rules) are sufficient to address the risk of carbon leakage and they clearly prefer a carbon tax at consumption level over any other alternative for a CBAM, while deeming a tax on imports at the EU border entirely irrelevant. However, the number of responses included in each of the two campaigns is not large enough to have a significant impact on the consultation results.

3. Methodology and tools for processing the data

The consultation activities allowed for the collection of data of both qualitative and quantitative nature, which were processed and analysed systematically. Qualitative data was structured according to key themes. Quantitative data (including survey responses and figures provided by stakeholders) was processed using Excel spreadsheet, and analysed using statistical methods, ensuring the appropriate protection of personal data without publishing the information of the respondents that did not give their consent.

4. Consultation results

1. Inception impact assessment feedback

Overall, the majority of replies (approximately 140) expressed support for the CBAM, with the remaining being roughly divided equally between limited and no support. The vast majority of responses expressed cautiousness in the design of the measure requesting to consider all options possible. Among others, key areas emphasized were the impact on value chains and reliance on imports of raw materials, avoidance of excessive effects on final consumers, links to EU ETS and free allowances, distributional impact in affected sectors and across countries, especially developing economies and interaction with existing trade defence measures on raw materials.

In more specific terms, some of the main concerns highlighted by stakeholders included: the negative impact on free trade and global supply chains, reduction of imports, harm to cross-border electricity infrastructure investment, the questionable existence of carbon leakage, WTO compatibility, the possibility of retaliatory trade measures and the need to protect the competitiveness of the EU industry. There were suggestions as to the sectoral scope and scope of emissions to be covered as well as the continuation of free allowances. Lastly, concerns were also expressed on the methodology to be adopted in the design of the measure and the potential administrative burden of the measure.

2. Targeted consultation

As he targeted consultation interviews focused on the perspective of stakeholders on the policy options the results will be discussed for each option. Responses broken down by stakeholder type and sector are presented in Table 2-2.

Regarding Option 1 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 4), albeit less of a long-term solution.

Option 6 (excise duty) 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.

The carbon added tax (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 2-2: Responses of targeted consultation by stakeholder type and sector

	No. of inter-views	***Option 1: CBAM on imports with auctioning (basic materials only)***	***Option 6: Excise duty with free allocation (materials also in manufactured products)***	***CAT 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	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	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	Welcome 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	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	Complexity of tracing actual emissions would require technology such as block chain. This option entails high fraud	Free allocation deemed necessary for transition; Resource shuffling under CBAM will

			materials; weakness that leakage protection depends on free allowance mechanism	risks	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 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	
Manufacturing	3	Fear of accumulation of burden in different countries; only basic materials seen as counteracting EU industrial strategies for manufacturing industries	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 EU ETS as most effective leakage protection; little concern about resource shuffling	Differing opinions: Shift of paradigm; needs long term alignment with EU 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

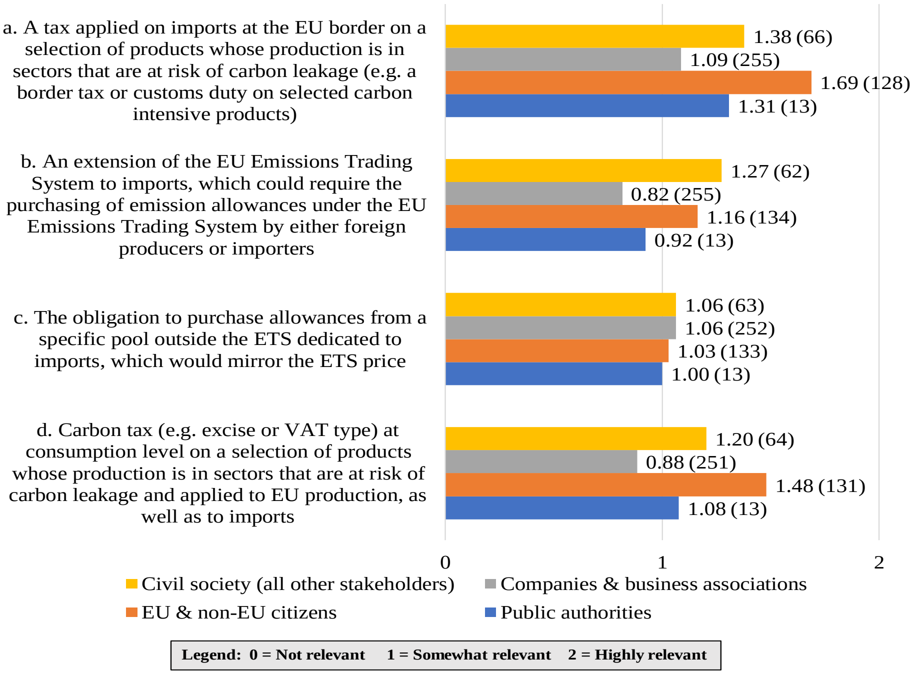
3. *Public Consultation*

A concerted effort was made to ensure that the views and concerns of all affected stakeholders were carefully considered throughout the impact assessment exercise. The public consultation gathered the views of the stakeholders on the problems presented, justification, design and impact of the proposed measure.

Respondents irrespective of group seem to indicate that a CBAM can be **justified** by differences of ambition between the EU and third countries when it comes to fighting climate change, and that it can contribute to both EU and global climate efforts. Citizens indicate most agreement, whereas responses from bordering countries show relative disagreement. Most do not believe that a CBAM would impose unnecessary burdens on the EU industry, however companies and business associations, as well as stakeholders in bordering countries are relatively more concerned on this point.

With respect to the problem of **carbon leakage**, most respondents (apart from those coming from bordering countries) appear to believe that carbon leakage is a real issue and that the CBAM can address carbon leakage, foster consumption of low-carbon products in the EU, and stimulate the deployment of low-carbon technologies and ambitious climate policies in third countries. On the effectiveness of current measures in the context of the EU ETS and state aid rules to limit carbon leakage, and on the ability of other regulatory measures to reduce greenhouse gas ('GHG') emissions companies, business associations and public authorities have a positive belief whereas citizens and other stakeholders are more critical. Finally, all stakeholder groups apart from public authorities which are neutral seem to disagree that the current measures under the EU ETS can address carbon leakage sufficiently in regards to enhanced climate ambitions in the EU.

Figure 2-2: Options for designing CBAM based on stakeholder group

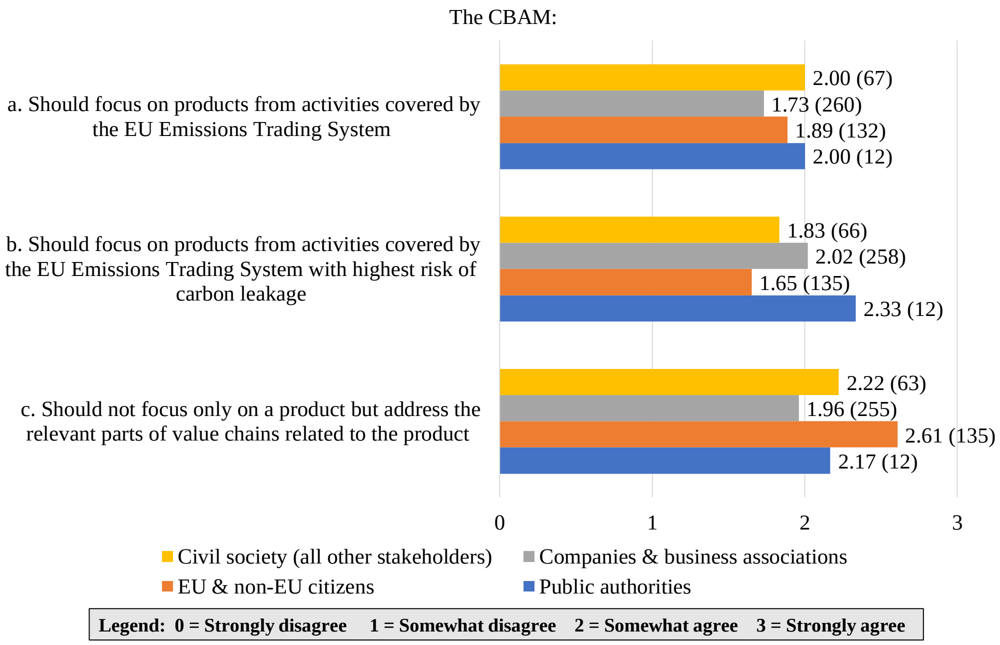


Source: Public consultation questionnaire responses

Regarding the **design** of the mechanism, responses appear to indicate that all policy options listed in the questionnaire are at least somewhat relevant for the design of a CBAM as can be seen in Figure 2-2. Companies are relatively less enthusiastic about all the proposed solutions and they attach limited relevance for the design of a CBAM to an extension of the EU ETS or a carbon tax on consumption, but they show a greater preference for the import tax. In addition, a carbon tax on imports has limited relevance for respondents based on bordering countries

Responses on the **product coverage** of the measure are presented on Figure 2-3. Respondents appear to suggest that the CBAM should focus on products from activities already included in the EU ETS (especially those with the highest risk of carbon leakage) and account for entire value chains.

Figure 2-3: Product Coverage



Source: Public consultation questionnaire responses

On **sectoral coverage**, each respondent was allowed to select up to 10 sectors in the online questionnaire. The following five sectors are selected more than 50 times by the 609 respondents:

i) Electric power generation, transmission and distribution.
ii) Manufacture of cement, lime and plaster.
iii) Manufacture of iron and steel and of ferro-alloys.
iv) Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber.
v) Extraction of crude petroleum.

In **implementation issues** there does not seem to be a consensus among respondents on the possible approach that can be applied to compute the carbon content of imported products. Respondents suggest that: i) both direct and indirect emission should be factored in; ii) emissions should account for the entire value chain of products in different countries; and iii) importers should have the possibility to demonstrate how the imported product was manufactured, in a verifiable manner. To a lesser extent, respondents appear to indicate that the approach should rely upon: i) the EU product benchmarks for free allocation under the EU ETS; and ii) the Commission product environmental footprint method.

Moreover, a number of respondents specified that the carbon content of imported products should be verified by an independent third party, with respondents from third countries showing less enthusiastic on that option. Furthermore most stakeholder groups disagreed with permitting self-certification, apart from public authorities. In addition, most participants and especially companies and business associations argued that the possibility to grant a rebate to EU exporters should be explored under the CBAM.

The majority of respondents in all stakeholder groups also expressed that the following avenues for circumvention would appear to pose significant risks to the correct functioning of the CBAM and should be prevented:

i) substitution between primary inputs and semi-finished goods;
ii) resource shuffling in the form of allocating low carbon production only to the EU;
iii) transhipment strategies via exempted third countries;
iv) avoidance based on minor modification of imported products.

The majority of the respondents seem to indicate that no exemption should be granted and that all imports should be subject to a CBAM on an equal footing with citizens being the greatest advocate of that and public authorities agreeing the least. Consulted stakeholders in all groups though, leave room for exempting partner countries with established climate policies that create incentives for emission reductions, similar to those in force in the EU. In contrast, there is no agreement in respect to granting credits for importing countries with climate policies generating carbon costs higher than in the EU.

On **expected impacts** the public consultation looked at economic, environmental and social impacts, as well as administrative burdens. On ***economic impacts***, the respondents collectively recognise that the CBAM would: i) encourage the consumption of low-carbon products; ii) have a positive impact on innovation; iii) have a positive impact on the competitiveness of the EU industry; and iv) have a positive impact on investment in the EU. They also appear to agree, however, that it would lead to increased costs for EU businesses in downstream sectors. However, companies, business associations and public authorities believe that the CBAM would impinge on EU exporters in the relevant sectors. In addition, respondents based in bordering countries argue the above effects to be negative instead of positive.

Environmental impacts are positive across all respondents, as they suggest that the CBAM would have positive would improve the effectiveness of policies against climate change, reduce carbon emission globally, and promote the adoption of ambitious climate policies in third countries. Business stakeholders are less convinced than other stakeholders on the extent this will be achieved, whilst stakeholders from bordering countries disagree on the effectiveness of CBAM to reduce carbon emissions on a global scale.

Social impacts are perceived to be both positive and negative. On the positive side, respondents seem to agree that the mechanism would avoid job losses in the EU, with business stakeholders questioning that. However, all stakeholder groups also appear to indicate that the CBAM may: i) increase the price of consumer products; ii) lead to job losses in downstream sectors; and iii) generate potential negative effects on the living standards of the poorer segments of the population.

Relating to the ***administrative burden***:

- About 95 % of respondents (478 out of 503) suggest that the CBAM could increase administrative burdens for exporters and importers.
- Almost 93 % of respondents (460 out of 495) envisage an increase in administrative burdens borne by public administrations in the EU.
- The majority of respondents (336 out of 480) appear to maintain that the CBAM is expected to generate relatively higher administrative burdens for Small and Medium-sized Enterprises (SMEs), however, almost one third of respondents appear to disagree with this conclusion.

It should be noted that the stakeholder group disagreeing with the above is citizens.

Lastly, the positions papers gathered by all stakeholder groups raised the following key challenges:

- Consideration of economic and environmental impacts.
- Technical design (e.g. Calculation of carbon content, default values).
- Balance the burden between EU and non-EU companies.
- Ensuring robust data collection and verification process.
- Retaliation measures.
- Implemented in a way to strengthen global climate ambition.
- Ensure competitiveness of EU industry on global market.
- Contributing to decarbonisation of sectors through innovation and investment.
- Definition of sectoral scope of CBAM and maintaining free allowances.
- Alignment with EU ETS.

5. Conclusions

The results of the public and targeted consultations allowed the Commission to collect a significant number of views and opinions on the initiative. Both public and targeted consultations showed agreement on the necessity of a CBAM to address the risk of carbon leakage and help the EU to achieve its increased climate ambitions.

Regarding the design options an import tax and a tax at consumption level are the most favoured by the public consultation. The targeted consultation shows greater preference for the excise duty option largely because of its retention of free allocation and disproof of the CAT due to its complexity and increased administrative burden. In addition, all consultations largely point to the same initial sectors for CBAM coverage.

With respect to expected impacts, the public consultation provides for positive economic and environmental impacts but mixed social impacts. This is partly confirmed by the targeted consultation which shows that environmental and economic impacts vary depending on the option. As for administrative costs the majority of respondents in both consultations believe they will be increased, with the targeted consultation specifying that for certain options.

Finally, it is worth noting that the feedback received throughout the public and the targeted consultations has been used to inform the choice of the design elements and the preferred policy options.

ANNEX 3: WHO IS AFFECTED AND HOW?

1. Practical implications of the initiative

The initiative would affect the following stakeholders:

- Private sector/industry.
- Public administration/Competent authorities.
- EU citizens.
- Least Developed Countries (LDCs).

(a) Private sector/industry

The proposal for a CBAM will increase costs for both imports and domestic production. Producers of basic materials have to pay a carbon price on their emissions. Imports of basic materials from third countries face carbon costs similar to the costs of European producers. The possibility to demonstrate that the carbon efficiency of their product is better than the default value, would increase costs, but this also provides emission reduction incentives for the share of materials that is exported to the EU.

Producers will face the following costs:

- Increase in carbon costs.
- Monitoring the quantity of imported products.
- Tracking the place of origin.
- Monitoring the embedded GHG 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 registry.
- Costs related to making the payment.
- Costs related to the preparation for controls by the authorities.
- Buying and surrendering of import certificates (CBAM certificates).

Compliance costs are likely to be higher for SMEs. These costs are detailed in Annex 6 for businesses and SMEs.

However, the investment in low carbon technologies will improve production efficiency and prepare businesses for more sustainable production processes.

(b) Administrative management of the CBAM

The EU will benefit from the increased revenues stemming from the CBAM. A detailed assessment can be found in Annex 6.

Public administration will face similar costs than businesses from a CBAM, with the main differences arising from assessing information and controlling the reports from economic operators. Costs linked to the establishment of a central CBAM registry are also foreseen.

Monitoring, Reporting and Verification (MRV) rules for the CBAM should be based on those in the EU ETS. To ensure synergies, there should be some coordination and learning between the respective competent authorities, and deadlines for the compliance cycle should be coordinated.

(c) EU citizens

Due to the implementation of a CBAM and the shift towards cleaner technologies, a limited increase on consumer prices is expected. In fact, prices across household consumption fall slightly with the exception of minor increases in vehicles and household equipment. The distributional impact of CBAM, although small, is progressive.

There is a loss of employment in sectors covered by the CBAM, by -1.20 %. The effects on other downstream sectors are minimal.

Altogether, and in line with the objective of the CBAM, EU citizens will benefit from a reduction in GHG emissions.

(d) Least Developed Countries (LDCs)

CBAM may give rise to unintended economic risks due to additional costs for exporters and deteriorating terms of trade. Many countries in the Global South, and on the African continent in particular, are exposed to relatively high risks. In order to avoid new global dividing lines between countries with a low- and high-carbon export structure, the EU should carefully assess risk levels and support the transformative process that partner countries would need to undertake to adjust to the CBAM .

LDCs are not among the EU's main importers. Excluding intra EU-27 trade, LDCs comprise less than 0.1 % of imports to the EU in Iron and Steel, Fertilisers, and Cement. At the same time, the relative importance of these exports for LDCs' economies can conversely be quite large. Mozambique is an important exception to otherwise negligible shares of LDCs in EU imports, as the country accounts for 7.7 %of the EU's imports of aluminium. In fact, 54.1 %of Mozambican Aluminium CBAM sector exports were to the EU. While the Iron, Steel and Fertiliser sectors have 3-4 LDCs importing relatively evenly, the Aluminium and Fertiliser sectors are dominated by Mozambique and Senegalese imports respectively when it comes to LDCs.

Table 3-1: Exports from LDCs to the EU in sectors likely impacted by CBAM[1]

Sector	CBAM Product	EU-27 5-year Average Imports From All LDCs (€ ,000)	Countries (LDCs With Over 70 % LDC-EU market share)	% Share	Remarks
Cement	Other Cement	98.4	Cambodia	33.1 %	Almost threefold increase 2018-2020
			Chad	28.9 %	2016 imports only
			Senegal	13.4 %	Mainly 2016 imports
	Portland Cement	26.4	Haiti	92.4 %	2019 imports only
	Clinker	1	Uganda	40.0 %	Single-year import data for each country
			Guinea, Mozambique, Senegal	20.0 % each	
Iron & Steel	Hot Rolled	575.4	Sierra Leonne	78.8 %	96.0 % decrease 18/19 95.2 % increase 19/20
	Primary Forms	387.8	Niger	99.7 %	2020 imports only
	Coated Hot-Rolled	263.8	Myanmar	51.1 %	Mainly 2017 imports
			Niger	21.1 %	2017 & 2019 imports only
	Forged, Extruded & Wire	63.6	Ethiopia	77.0 %	2018 imports only
Aluminium	Aluminium Products	835,047.0	Mozambique	100.0 %	
	Unwrought Alloyed & Alloyed	15,201.8	Mozambique	87.1 %	Volatile. 99.6 % drop in 2020 from peak in 2018
Fertilisers	Mixed N Fertiliser	2,298.2	Senegal	94.3 %	2017 & 2018 imports only
	Other Fertilisers	474.6	Senegal	55.9 %	2018 & 2019 imports only
			Madagascar	16.0 %	
	Urea	1.8	Afghanistan	100.0 %	2019 imports only
	Nitric Acid	1.8	Ethiopia	100.0 %	2017 imports only

Source: DAI (2021). Supplementary Analysis to the Impact Assessment on the European Commission's Carbon Border Adjustment Mechanism, commissioned by the European Commission's Directorate-General for International Partnerships (internal document)

Some key takeaways from the product level data include:

- Imports of other cement from Cambodia to the EU-27 have increased threefold between 2018-2020.
- Portland Cement only has one substantial import value from Haiti, all due to one-time imports in 2019.
- Imports of clinker from LDCs to the EU-27 are not substantial.
- CBAM Iron & Steel product imports from LDCs fluctuate annually, with several LDCs trading large quantities one year, to trading small (or zero) amounts the next year. This is also true for Mixed N and Other Fertilisers.
- Mozambique comprises nearly 100 percent of all CBAM Aluminium Product LDC imports to the EU-27.

[1] Products coverage is indicative. The final CBAM proposal may include additional subcategories of sectors

- No LDC imports in Ammonia were recorded to the EU-27 over the last 5 years. Urea and Nitric Acid imports from LDCs are relatively insignificant.

The carbon emissions resulting from LDCs' imports into the EU across the sectors tentatively reviewed for possible CBAM application are proportionately limited relative to those of other EU trading partners globally. It should be recognised nevertheless that those sectors do contribute to the economies of certain LDCs. The table below illustrates the proportional importance of these sectors in main LDC countries.

Table 3-2: Relative importance of certain CBAM sectors in main LDC countries

Country	**Activity**	**GDP Contribution (%)**
Mozambique	*Aluminium*	Exports to EU accounted for nearly 7 % of GDP in 2020 – GDP contribution of sector around 13 %
Mauritania	*Iron Ore*	10-18 % per IMF projections – depends on iron prices
Sierra Leone	*Iron Ore*	Fluctuates per iron price – 2.48 % in 2017, 15.4 % in 2013
Senegal	*Phosphate mining & Fertiliser Production*	~2 - 5 %

Finally, compliance costs are likely to be higher in LDCs relative to developed countries where governments, sectors and firms will have more capacity and access to expertise to facilitate verification and compliance. This includes institutions in charge of accreditation, availability of certification bodies and data on carbon intensity (needed for identifying carbon embedded in exports to the EU under CBAM). On the private sector side, LDC businesses are likely to on average have lower capacity than larger companies, in more advanced countries, to be able to comply with such procedures.

2. Summary of costs and benefits

Table 3-3: Overview of Benefits for Preferred Option – Option 4

I. Overview of Benefits (total for all provisions) – Preferred Option		
Description	***Amount***	***Comments***
Benefits		
Supporting reduction of GHG Emissions	Impact on carbon dioxide (CO_2) emissions in the CBAM sectors in EU27 and rest of the world (% change from MIX with free allocation in 2030): - **-1.0 %** in the EU in 2030 - **-0,4 %** in the rest of the world in 2030	By reducing GHG emissions in the EU, CBAM will enable the EU to achieve its increased targets for 2030 and become carbon neutral by 2050.
Preventing carbon leakage in CBAM sectors	Under option 4, carbon leakage in CBAM sectors is brought down to -29 % in 2030	Preventing carbon leakage is important to ensure that global emissions and imports of carbon embedded products do not rise as a result of the relocation of industry from EU.
Revenue generation	The yearly revenue stemming from CBAM is expected to be around: **EUR 9.1 billion in 2030** (7 billion EUR from auctioning and 2.1 billion EUR from CBAM)	- Revenue generated is made up of both the revenues from the CBAM itself, and from additional auctioning in the CBAM sectors

Table 3-4: Overview of costs for Preferred Option – Option 4

II. Overview of costs – Preferred option								
		Citizens/Consumers		Businesses		Administrations		
		One-off	Recurrent	One-off	Recurrent	One-off	Recurrent	
Economic and social costs in the EU	Direct costs		- Overall small decrease in aggregate consumption of 0,56 % - expected limited increase in electricity prices - expected limited increase vehicle and household equipment products	Cost of new technologies	Compliance costs (See below)	None	None	
	Indirect costs	- minimal loss of employment in downstream sectors		None	None	None	None	

Enforcing CBAM[2]	Direct costs	None	None	None	- compliance costs for quantification of emissions, documentation, reporting - Higher compliance costs for SMEs - compliance costs for buying and surrendering CBAM certificates	- setting up systems (e.g. CBAM registry) - setting up system for certificates	- Enforcement costs on processing documents, payments and controlling goods. - Cost of administering registry accounts for transactions of CBAM certificates - Costs for monitoring, verification and reporting of carbon content
	Indirect costs	None	None	None	None	None	None

[2] See Annex 6 for further details.

ANNEX 4: ANALYTICAL METHODS

1. Introduction

In order to assess the environmental, macro-economic, and distributional impacts of the CBAM, the analysis used three modelling tools: (1) JRC-GEM-E3, a computable general equilibrium model; (2) Euromod, a static microsimulation model; (3) PRIMES model (Price-Induced Market Equilibrium System), a large-scale applied energy system model that was employed specifically for the modelling of the electricity sector.

2. The JRC-GEM-E3

Overview

JRC-GEM-E3[3] (General Equilibrium Model for Economy-Energy-Environment) is a recursive dynamic Computable General Equilibrium model. It is a global model, covering the EU, alongside 12 other major countries or world regions. With a detailed sectoral disaggregation of energy activities (from extraction to production to distribution sectors) as well as endogenous mechanisms to meet carbon emission constraints, the JRC-GEM-E3 model has been extensively used for the economic analysis of climate and energy policy impacts.

Divided into 31 sectors of activity, firms are cost-minimizing with Constant Elasticity of Substitution (CES) production functions. Sectors are interlinked by providing goods and services as intermediate production inputs to other sectors. Households are the owner of the factors of production (skilled and unskilled labour and capital) and thereby receive income, used to maximize utility through consumption. Government is considered exogenous, while bilateral trade-flows are allowed between countries and regions using the Armington trade formulation where goods from different goods are imperfect substitutes.

In 5-year steps, an equilibrium is achieved at goods and services markets, and for factors of production through adjustments in prices.

The model integrates (in particular for the baseline building) inputs from energy system models (generally PRIMES for EU Member States and POLES-JRC for the rest of the world) on a number of variables of interest, such as a detailed use of energy products by consumers, global fuel prices, etc. More information on the integration of energy system model inputs in macroeconomic modelling in JRC-GEM-E3, can be found in the Impact Assessment of the Climate Target Plan (CTP) - Annex 9.3[4].

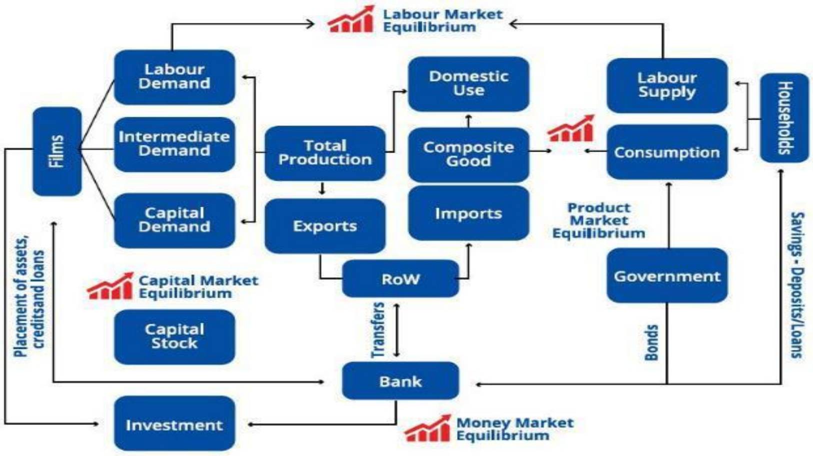
The JRC-GEM-E3 model is normally used to compare (various) policy options against a baseline scenario, representing the evolution of the global economy under current energy and climate policies.

---

[3] https://ec.europa.eu/jrc/en/gem-e3/model

[4] European Commission. (2020). Stepping up Europe's 2030 climate ambition. (COM(2020) 562 final). Part 2: https://ec.europa.eu/transparency/regdoc/rep/10102/2020/EN/SWD-2020-176-F1-EN-MAIN-PART-2.PDF

Figure 4-1: A schematic representation of the GEM-E3 model.



Source: JRC-GEM-E3 model

The model can be used to assess the impacts of the energy and climate policies on macroeconomic aggregates such as GDP and employment. The most important results provided by JRC-GEM-E3 are: Full Input-Output tables for each country/region identified in the model, dynamic projections of national accounts by country, employment by economic activity and unemployment rates, capital stock, interest rates and investment by country and sector, bilateral trade flows, private and public consumption, consumption matrices by product and consumption purpose, GHG emissions by country, energy demand by sector and fuel, power generation mix, energy efficiency improvements.

Sources for main data inputs:

- Eurostat, GTAP and Exiobase: Input Output tables, National Accounts, Employment, Institutional Transactions, Labour force, Bilateral Trade, Capital stock, Taxes and tariffs, Household consumption by purpose
- Ageing Report and ILO: Employment, Unemployment rate
- PRIMES and POLES-JRC: Energy and emission projections

Adjustments to the JRC-GEM-E3 model

In order to capture the effect on some important sectors for which CBAM might be applied, the sectoral granularity of the JRC-GEM-E3 model was improved for the purposes of the modelling analysis. This exercise allowed for the model's underlying database to explicitly feature:

- aluminium
- fertilisers
- cement (and lime)
- iron and steel.

The main difficulty in splitting aluminium, fertilisers, cement (and lime) out of the more aggregate non-ferrous metals, chemicals, non-metallic minerals sectors was to obtain adequate data to inform cost and use shares of the sectors[5]. Important aspects included capturing the emission and trade intensities of the sub-sectors as these are determinants of how effective leakage protection measures will be[6]. The GTAP 10 database[7] which is used as the main economic data source of the JRC-GEM-E3 model does not break out these subsectors. EXIOBASE[8], another global input output table, does include these subsectors, and is used to determine cost and trade shares, including the trade intensity of the subsectors. It is however not advisable to run JRC-GEM-E3 with only relying on Exiobase due to the richer representation of taxes, subsidies, trade costs, etc. in GTAP.

In view of the above, the analysis integrated the Exiobase information into the GTAP database. In particular the analysis used GTAP data for the sectors not affected and constrained the sums of the subsectors to match the overall GTAP data. For example in the present data set aluminium and other non-ferrous metals sum up to the value of the non-ferrous metals sector in GTAP. This exercise was further augmented by cross-checking against additional data provided by DG CLIMA on emissions intensity of EU ETS sectors by the Statistical Classification of Economic Activities in the European Community (NACE) codes in the EU member states and adjusting where necessary. The final dataset was compared again to the emissions reported in the European Union Transaction Log database to confirm that key characteristics are captured.

Description of the baseline

The starting point of the analysis is the PRIMES EU Reference Scenario 2020, which is the common baseline for the Fit for 55 impact assessments. It provides projections for energy demand and supply, as well as GHG emissions in all sectors of the European economy under the current EU and national policy framework. It embeds in particular the EU legislation in place to reach the 2030 climate target of at least 40 % compared to 1990, as well as national contributions captured in the National Energy and Climate Plans to reaching the EU 2030 energy targets on energy efficiency and renewables under the Governance of the Energy Union. Projections for GDP, population and fossil fuel prices take into account the impact of the COVID crisis and are aligned with the 2021 Ageing Report. A more detailed description can be found in the impact assessment covering the revision of the ETS Directive.

The implementation of the EU Reference scenario into JRC-GEM-E3 is using the Piramid methodology[9], reproducing the energy balances of the PRIMES model for the EU Reference scenario and being fully harmonized with the macro data used to drive PRIMES for the EU (and UK)[10]. For non-EU regions (except UK), energy balances were taken from POLES-JRC, in particular the model runs produced for the Global Energy

[5] Cost shares refer to the relative importance of different inputs in the cost of a sector to produce a unit of output, while use shares refer to the share of which products are used by other sectors as intermediate goods or as final goods.

[6] https://doi.org/10.1016/j.eneco.2012.08.015

[7] https://www.gtap.agecon.purdue.edu/

[8] https://www.exiobase.eu/

[9] See https://ec.europa.eu/jrc/en/macroeconomic.baselines.for.policy.assessments

[10] As PRIMES energy balances do not explicitly specify the sub-sectors split out, assumptions are made to project energy use and emissions in the subsectors. In general, it is assumed that sub-sectors experience the same growth rates as the overall sector represented in PRIMES and that relative emission reductions are equal in sub-sectors.

and Climate Outlook 2020[11]. These also take into account the macroeconomic consequences of COVID-19 and likely (persistent) changes in the transportation sector.

The CBAM has to be seen in the context of a policy environment achieving -55 % emission reductions. For the modelling underlying this impact assessment, this policy context is mainly represented by the use of the MIX scenario. The MIX scenario achieves a reduction in net greenhouse gas emissions of 55 % compared to 1990 levels and of around 53 % excluding LULUCF. The GHG target includes intra-EU maritime and intra-EU aviation emissions in its scope. The scenario relies on both carbon price signal extension to road transport and buildings and strong intensification of energy and transport policies to achieve the higher GHG target. In the JRC-GEM-E3 model, the EU ETS is assumed to be expanded to also cover buildings and road transport, with full auctioning in these sectors. Free allowances are assumed to cover 100 % of emissions of energy intensive industries at risk of leakage. The scenario is implemented with a 'soft coupling' to the PRIMES model. This means that the scenario is using certain input values from the PRIMES model results for housing, transport and electricity sector, as well as providing guidance to set emission targets for (expanded) EU ETS and emission reduction potential for industrial process emissions.

As indicated in the main report, this impact assessment is drafted in parallel with the impact assessment on the revision of the ETS directive that sets out a number of scenarios for the strengthening of the existing EU ETS on power and industry installations. Each of these options have an impact on the evolution of free allocation. In view of this and to complement the analysis on the carbon leakage prevention framework, a variant of the MIX is also modelled depicting the case of complete removal of free allowances in the CBAM sectors[12], in the absence of a CBAM.

Closure rules and key assumptions

Various alternative modelling assumptions were explored with the JRC-GEM-E3 model. For the purposes of this analysis, the focus is on the results based on budget neutrality, where government budgets are held fixed to baseline values relative to GDP with additional revenue provided as reductions of labour taxation[13] and allowing for the imperfect labour market to adjust after the policy shock.

Moreover, firms are assumed to fully pass on the value of free allowances to consumers ('market share maximisation'). This market share maximization behaviour implies a zero pass though rate, i.e. firms are assumed to not pass through the opportunity cost of selling permits that they have received for free. While the empirical literature provides evidence of some pass through of opportunity costs depending on sector characteristics such as

---

[11] Keramidas, K., Fosse, F., Diaz-Vazquez, A., Schade, B., Tchung-Ming, S., Weitzel, M., Vandyck, T., Wojtowicz, K. Global Energy and Climate Outlook 2020: A New Normal Beyond Covid-19, doi: 10.2760/608429, JRC123203.

[12] CBAM sectors refer to sectors where CBAM is considered as a possible alternative to free allocation of allowances under the EU ETS.

[13] This modelling approach ensures budget neutrality, rather than defining how additional revenues from CBAM as an own resource could be used. The introduction of CBAM and the associated own resource hence lowers the need of Member States contributions to maintain the same budget, lowering the need to raise revenue through (e.g. labour) taxes

market concentration[14], revisions to the EU ETS will couple free allowances tighter to output values. The economic literature suggests that this would reduce or even eliminate pass through. The modelling approach without pass through is conservative, as it indicates larger consequences when moving from free allowances to full auctioning. The effect of adding CBAM on top of full auctioning would however be very similar regardless of the assumption on cost pass through.

3. Euromod

The estimates of the distributional impacts of the CBAM scenarios use Euromod, the European Union tax-benefit microsimulation model[15]. The Euromod model combines country-specific coded policy rules with representative household microdata (mainly from the European Union Statistics on Income and Living Conditions database, EU-SILC). The model employs information on countries' tax and benefit policy rules and on household characteristics and economic circumstances to simulate tax liabilities and cash benefit entitlements. Taxes and transfers that are not possible to simulate because of lack of relevant information are used as recorded in the original surveys. The model simulations take into account the role played by each tax-benefit instrument, their possible interactions, and generate the disposable (i.e. after taxes and cash benefits) household income[16]. Therefore, the model results are particularly suitable for the analysis of the distributional, inequality and poverty impact of tax changes, by households or groups according to socio-economic variables of interest. Cross-country comparability is enabled by coding the policy systems of the EU Member States according to a common framework and from the harmonization of the underlying microdata. Euromod simulations also provide estimations of the budgetary effects and indicators which are commonly used to measure work incentive effects of the policy scenarios.

It should be kept in mind that Euromod simulations do not incorporate any behavioural effects that may also affect the (second-round) fiscal as well as the distributional outcomes of a policy change. Thus, the model is static and delivers the first-round effects (`the overnight effect').

The analysis of the CBAM scenarios is based on the recently developed Indirect Tax Tool version 3 (ITTv3) extension of the Euromod model[17]. The ITT allows the simulation of indirect taxes (VAT and excises) and their impact on household and government budgets. In order to simulate these indirect tax liabilities, the ITT uses the underlying microdata of Euromod (primarily based on EU-SILC) combined with imputed private household expenditure information for more than 200 commodity categories from the harmonised Eurostat Household Budget Surveys (EU HBS). The tool applies the indirect taxation rules in place in each country (including VAT, specific and ad-valorem excises) to compute households' indirect tax liabilities based on their imputed

[14] Cludius, Johanna & de Bruyn, Sander & Schumacher, Katja & Vergeer, Robert, 2020. 'Ex-post investigation of cost pass-through in the EU ETS - an analysis for six industry sectors', Energy Economics, Elsevier, vol. 91(C).

[15] For more detail see https://euromod-web.jrc.ec.europa.eu/about/what-is-euromod

[16] The main income inequality and poverty indicators which are used to evaluate the impact of CBAM are generally based on *equivalised* household disposable income, considering economies of scale in consumption within the household: *equivalised* income refers to the fact that household members are made equivalent by weighting them according to their age, using the so-called modified OECD equivalence scale.

[17] For more detail see https://euromod-web.jrc.ec.europa.eu/about/extended-functionalities

consumption basket. Currently, the ITT rests on the assumption of full tax compliance and of full pass-through, and it is available for 18 countries (BE, CY, CZ, DK, FI, FR, DE, EL, ES, HU, IE, IT, LT, PL, PT, RO, SI and SK).

The simulations conducted in this analysis are based on Euromod version I2.0. The tax-benefit systems simulated in the baseline refer to those in place in each country as of June 2019, while the underlying input data mainly come from the 2010 EU-SILC[18] and the 2010 HBS. Incomes reported in the EU-SILC of 2010 refer to 2009-2010. Uprating factors are used to update income and prices from the date of the input data to the year of interest, in this case 2019.

The distributional impact of the CBAM scenarios is analysed by estimating the changes in household adjusted disposable income (the disposable income[19] after the payment of indirect taxes) across the income distribution. Changes in household adjusted disposable income in the CBAM scenario under consideration are compared against the counterfactual (tax-benefit systems in place in 2019).

For the simulations of the CBAM options, the Euromod-ITT has been linked to the JRC-GEM-E3 macroeconomic model to account for the economy-wide impact of the reforms. Two main steps are followed to link the two models. In the first step, the baseline scenarios of the two models are aligned[20]. For this end, the consumption of each household in the ITT is adjusted proportionally in order to ensure that the aggregate share of consumption expenditure by each group of goods and services (e.g. 'Education' or 'Food') matches the one in the JRC-GEM-E3 model. In the second step, Euromod is fed with the impact of the simulated carbon-adjustment mechanism over prices and incomes, as simulated by JRC-GEM-E3. In more detail, the consumption expenditure of each household is adjusted to account for the changes in prices, while keeping constant the quantities consumed in each category. Furthermore, household income is also adjusted to account for the changes in labour and capital income triggered by the introduction of CBAM, as simulated by the JRC-GEM-E3. It should be noted that the recycling of the revenues from the carbon-adjustment mechanism is done through a budget-neutral reduction of labour income taxation, which is performed within the JRC-GEM-E3 model. The changes in labour income that feed the micro simulations from the macro model include the effect of this compensatory measure (alongside with the direct impact of the CBAM on prices and incomes mentioned above).

This procedure rests on two key assumptions affecting the estimation of the change in the indirect tax burden for households. First, in the CBAM scenarios, households are assumed to continue consuming the same quantities of all goods and services as before. This can be interpreted as consumers' demand being inelastic or the 'overnight effect' (households do not adapt their consumption basket after the change in price

[18] While there are more up to date EU-SILC data, the 2010 version was chosen to match the latest EU-HBS dataset available for the imputation of consumption data.

[19] Household market income net of direct taxes and cash benefits.

[20] There are a number of reasons for the baselines of Euromod and JRC-GEM-E3 not to be necessarily aligned in a given year. One of them is that Euromod and JRC-GEM-E3 variables are constructed in accordance to different sets of statistics: for example, while in JRC-GEM-E3 household consumption is aligned with National Account data, consumption is recorded from survey data in Euromod.

immediately). That effectively rules out any offsetting effects via reduced demand.[21] Second, estimations of the changes in consumer prices resulting from the CBAM are calculated with the JRC-GEM-E3 model. This means impacts on producer prices are captured in the general equilibrium solution of the CGE model, but are exogenous to Euromod.

4. PRIMES

The PRIMES model, was employed to assess CBAM for the electricity sector. PRIMES model (Price-Induced Market Equilibrium System[22]) is a large-scale applied energy system model that provides detailed projections of energy demand, supply, prices and investment to the future, covering the entire energy system including emissions. The distinctive feature of PRIMES is the combination of behavioural modelling (following a micro-economic foundation) with engineering aspects, covering all energy sectors and markets. The model has a detailed representation of instruments policy impact assessment related to energy markets and climate, including market drivers, standards, and targets by sector or overall. It simulates the EU Emissions Trading System in its current form. It handles multiple policy objectives, such as GHG emissions reductions, energy efficiency, and renewable energy targets, and provides pan-European simulation of internal markets for electricity and gas.

PRIMES offer the possibility of handling market distortions, barriers to rational decisions, behaviours and market coordination issues and it has full accounting of costs (CAPEX and OPEX) and investment on infrastructure needs. The model covers the horizon up to 2070 in 5-year interval periods and includes all Member States of the EU individually, as well as neighbouring and candidate countries. PRIMES is designed to analyse complex interactions within the energy system in a multiple agent – multiple markets framework. Decisions by agents are formulated based on microeconomic foundation (utility maximization, cost minimization and market equilibrium) embedding engineering constraints and explicit representation of technologies and vintages; optionally perfect or imperfect foresight for the modelling of investment in all sectors.

PRIMES allows simulating long-term transformations/transitions and includes non-linear formulation of potentials by type (resources, sites, acceptability, etc.) and technology learning. It is a private model maintained by E3Modelling[23], originally developed in the context of a series of research programmes co-financed by the European Commission. The model has been successfully peer-reviewed and team members regularly participate in international conferences and publish in scientific peer-reviewed journals.

For the simulation of the effects of the CBAM in the electricity sector, the PRIMES electricity sector model is employed to project scenarios with and without the CBAM to assess the impacts on the power generation mix, investment, costs, prices and carbon emissions.

[21] It is generally the case that when the price of a good rises (e.g. because an increase in taxation) the demanded quantity decreases. Empirically, price elasticity of demand are typically found to be in the range of (-1, 0).

[22] More information and model documentation: https://e3modelling.com/modelling-tools/primes/

[23] E3Modelling (https://e3modelling.com/) is a private consulting, established as a spin-off inheriting staff, knowledge and software-modelling innovation of the laboratory E3MLab from the National Technical University of Athens (NTUA).

The basic projection for the EU countries reflects the assumptions of the MIX scenario, based on the PRIMES model, as available in end January 2021. The alternative scenarios assume that the CBAM mechanism increases the unit cost of imports of electricity from third countries not applying carbon pricing, which induces a restructuring of electricity trade and readjustment in the fuel and capacity mix in the EU countries.

The analysis considered the period of 2025–2030. The model simulates optimal expansion and operation of the power system and handles power exchanges over the interconnection system simultaneously. The simulation fully includes all the EU countries, the UK, Norway, Switzerland and the Energy Community contracting parties (with the exception of Georgia). Exports from Russia are part of the simulation and are price elastic with respect to the CBAM obligation.

The PRIMES model of the power sector performs optimal (least-cost) capacity expansion and system operation of the interconnected system inter-temporally in the period 2025–2030. The unknown variables are investment in power generation plants and storage facilities, the hourly operation of plants, storage facilities and the cross-border flows, which respect a DC-linear power flow model. Demand for electricity is given, as projected for the MIX scenario; similarly heat and steam produced by cogeneration units is fixed, as projected in the MIX. Fuel costs, technical efficiencies and other parameters, the EU ETS carbon prices and the non-linear cost-potential curves for resources and plant siting are exogenous data. The model handles power plants individually, considers various types of investment decisions (e.g. greenfield, brownfield or refurbishment investment) and includes technical restrictions on their operation.

After projecting capacity expansion, operation and flows, the PRIMES power sector model calculates costs and revenues following a simulation of stylised wholesale markets and determines electricity tariffs per sector. The calculation of tariffs per sector of consumption takes care to recover all generation and grid costs and considers differentiation of prices by sector based on a simulation of retail supply that reflect a matching of load profiles and generation portfolios profiles as in bilateral contracts. Import and export prices reflect wholesale market prices.

ANNEX 5: DEFINITIONS

- **Raw materials**: Materials which are at the beginning of any value chain and are 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 used in a production process. Zero carbon content is assigned 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** (also referred to as semi-finished products): 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 but may replace parts of a final product.
- **Final products:** 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.
- **Production process/production step**: a single operation which adds value to one of the material or product categories listed above, resulting in another material or product.
- **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). Longer value chains reach 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', if those processes and GHG emissions are listed as an activity in Annex I of the EU ETS Directive[24]. 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.

[24] Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814 (OJ L 76/3).

- **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].
- **CBAM registry:** secure electronic registry system of CBAM importers at EU level. It would have to link to the relevant customs databases, manage the data of the 'CBAM importers', allow access for the relevant competent authorities and verifiers, and should store all emission data of installations in third countries which report emissions for the purpose of the CBAM. For the CBAM designs involving the surrender of CBAM certificates, the data stored in the CBAM registry will be used by the Central Administrative CBAM Body to recognize CBAM importers eligible to buy CBAM certificates and to fulfil the necessary monitoring and verification of surrendering sufficient CBAM certificates and accounting for any carbon price paid abroad by the importers.
- **CBAM Authority/National authorities tasked with CBAM:** Body(ies) assigned the task of selling CBAM certificates and conducting monitoring and verification of importers surrendering sufficient CBAM certificates to cover for embedded emissions in imported materials. In a centralised model, the body would be a central CBAM authority, while in a decentralised model these tasks would be carried out by national authorities.
- **CBAM certificate:** One certificate covers one tonne of CO_2 equivalent emissions embedded in imported materials and is part of CBAM designs involving the surrender of certificates to a Central Administrative CBAM Body as part of a reconciliation process.
- **Carbon pricing:** A price on GHG emissions can take the form of an emissions trading scheme or a carbon tax. Pricing of GHG emissions in the EU ETS is an important instrument of the EU's policy package to support the transformation of industries towards climate neutrality. This is because it varies only slightly between Member States and it also results in direct price differences between production at different origins, creating the need to prevent the risk of carbon leakage. 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 GHG 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 a need for global emissions reductions as agreed in the Paris Agreement.

ANNEX 6: COMPLIANCE COSTS FOR BUSINESSES

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.

Structure

The assessment of compliance and enforcement costs considers the different design elements of setting up the various options of 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 to only 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 set-up:

1. Whether the choice of instrument is an import tax, uses import certificates (CBAM certificates) or an excise duty system;
2. Whether the mechanism relies fully on default values or is one in which importers to claim individual treatment based on actual emission.

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 data that economic operators need to be able to provide to authorities or 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 an 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 certificates.

For 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 duty, this data was not available in a similar way to the options using CBAM certificates or an import tax.

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 based on similar elements in instruments such as the EU ETS, national emissions trading systems, existing excise duties or import taxes as well as the Clean Development Mechanism (CDM[25]) as an international instrument that monitors emissions from international installations and projects. Therefore, it is a central assumption of this assessment that CBAM cost

[25] https://cdm.unfccc.int/index.html

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 as well as excise duties, 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 digitalization of customs and tax procedures in the EU. The estimations on the number of imports, businesses or installations is based on data from industry associations, reports prepared for the EU Commission as well as EU and national databases on tax and customs.

Some data sources are academic papers, while many 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 an option in relation to the others. As such, research articles find that compliance costs for customs and excise duty instruments are the lowest of all tax instruments[26][27]. 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[28].

Overall, the estimations provided in this report are based on instruments that have been in place for multiple 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 implementations.

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:

- 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 based on 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 costs – of providing the information to authorities lies with the importers.

[26] Eichfelder, S., & Vaillancourt, F. (2014). Tax compliance costs: A review of cost burdens and cost structures. arqus Discussion Paper No. 178.
[27] Smulders, S., Stiglingh, M., Franzsen, R., & Fletcher, L. (2012). Tax compliance costs for the small business sector in South Africa—Establishing a baseline. EJournal of Tax Research, 10(2), 44.
[28] Barbone, L., Bird, R. M., & Vazquez-Caro, J. (2012). The Costs of VAT: A Review of the Literature. CASE Network Reports.

- 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.
- As already mentioned above, the CBAM is assumed to result in comparable costs as existing, similar mechanisms. However, the CBAM will target imports of products and their embedded emissions. Therefore, costs from existing mechanisms of monitoring installations' emissions are generally doubled to create an estimation for the production of multiple products in one installation. This is estimated 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 sectors steel, cement, aluminium, polymers, fertilisers and petrochemicals. 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 import EU ETS.
- For the assessment of the cost of individual treatment based on actual embedded emissions, the number of relevant global installations is estimated based on the number of EU installation and the relation between EU production and imports[29]. The total number could in reality be lower due to importers deciding to import from fewer installations to increase efficiency of MRV obligations.
- The number of import actions per year is estimated based on imported quantities in relation to the average share of import modes for sea road and rail[30]. Because of the nature of basic materials, a high 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 based on the number of Authorised Economic Operators[31]. The share of affected importers is assumed to reflect the share of import value of the mentioned basic materials out of the value of all EU imports[32].
- 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.

---

[29] Data sources: publicly available industry data from European Aluminium, CEFIC, PetrochemistryEU, Ecorys et al. 2019, and the US International Trade Administration.

[30] 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

[31] See: https://ec.europa.eu/taxation_customs/general-information-customs/customs-security/authorised-economic-operator-aeo/authorised-economic-operator-aeo_en

[32] Data sources: industry data, Eurostat, 2020: https://ec.europa.eu/eurostat/statistics-explained/index.php/International_trade_in_goods

- The creation of an excise duty would oblige domestic producers and businesses in the value chain. Therefore, the introduction of an excise duty is assumed to create comparable cost elements as the existing excise duties (e.g. on tobacco or alcohol). In contrast to other existing excise duties on goods like alcohol or tobacco, it is assumed that real-time tracking through the Excise Movement Control System[33] is not necessary, because of the low excise duty 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.

Table 6-1: 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: estimations based on industry and statistical data[34]

For an excise duty 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

[33] See: https://ec.europa.eu/taxation_customs/business/excise-duties-alcohol-tobacco-energy/excise-movement-control-system_en

[34] 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/

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 duty 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.

1. **Assessment of compliance costs for businesses**

Following the general remarks and assumptions laid 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 duty option. The former comprises the implementation through the surrender of import certificates (CBAM certificates) and the payment of an import tax.

On the one hand, design **options 1 to 5** rely on an adjustment of carbon price at the border using the payment options of an import tax or import certificates. For those 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 of actual emissions. This includes:
  - Monitoring the quantity of imported goods.
  - Tracking the place of origin.
  - Monitoring the embedded carbon emissions of goods 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 registry.
- Costs related to making the payment.
- Costs related to the preparation for controls 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 goods 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 cause no substantial costs. However, in an option that sees importers to 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[35].

[35] Krey, M. (2004). Transaction Costs of CDM Projects in India – An Empirical Survey. Hamburg Institute of International Economics.

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 in the case of a possibility to deviate 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. Estimations for the CDM, however, indicate a span for verification costs[36] 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 not a definite amount.

As second cost element, the documentation and reporting of the quantities and emissions is assessed based on the reporting costs estimated under the EU ETS for UK businesses. Based on this, the estimation is of EUR 900 per year and 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 fewer information needed to be documented 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 relation of the importer with authorities involving tax and customs payments is assumed.

Finally, the costs of preparation for controls are included, for options of claimable actual emissions, in the costs for MRV described before. 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 6-2 summarises the above. In total, the sum of yearly standardised cost estimations amounts to EUR 5 400 per importer for options entirely based on default values.

In contrast, options where claiming actual emissions is possible result in total yearly costs between EUR 30 800 and EUR 43 800 for 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[37]. 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.

[36] Talbot, A. (2016). ASSESSMENT OF COSTS TO UK PARTICIPANTS OF COMPLIANCE WITH PHASE III OF THE EU EMISSIONS TRADING SYSTEM. Department for Business, Energy & Industrial Strategy. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/799575/Cost_of_Compliance_Report.pdf

[37] Destatis OnDEA database, calculation for 1 900 EU ETS participants: https://www.ondea.de/SiteGlobals/Functions/Datenbank/Vorgaben/Einzelansicht/Vorgabe_Einzelansicht.html?cms_idVorgabe=12746

Table 6-2: Annual compliance costs estimates per importer (in 1 000 EUR) for a CBAM implemented as an import tax.

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 goods	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[38])	**5.4**	**30.8–43.8**

Sources: Krey 2004, Talbot 2016, Destatis OnDEA database

The result for overall yearly costs for EU businesses is calculated based on 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 are submitting 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.

[38] Unit differs between third-country installations for MRV and inspection costs, and importers for documentation.

Import certificates

As the cost assessment for an implementation using import certificates (CBAM certificates) 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 certificates to be surrendered, documentation and control are assumed to be similar to costs 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 CBAM certificates – creates new costs to businesses. Additionally, the costs of having a registry account contributes between EUR 0 and EUR 800[39]. Thus, based on this and assessments of national EU ETS implementation these costs are quantified between EUR 40 and EUR 1 500 per year and participant[40].

Table 6-3 summarises the costs for the import certificates 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 45 300 per year.

Table 6-3: Compliance costs estimates per importer (in 1 000 EUR) for a CBAM implemented through CBAM certificates.

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 goods	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 import certificates (CBAM certificates)	0.04–1.5	0.04–1.5

[39] Umweltbundesamt, 2015. Evaluation of the EU ETS Directive
[40] Destatis OnDEA database: https://www.ondea.de/DE/Home/home_node.html; Talbot, 2016

Inspection and audit costs to be prepared for verification by authorities	negligible extra burden	12
Total (standardised costs[41])	**5.44–6.9**	**30.84–45.3**

Sources: Krey 2004, Talbot 2016, Destatis OnDEA database

Again, the result for overall yearly costs for EU businesses is calculated based on the estimates and the number of cases. For CBAM implemented as the surrender of CBAM certificates 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 CBAM certificates 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 are submitting 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 complete 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 duty option considers as design elements (1) only the reliance on default values for the quantification of the excise duty, and (2) always includes the downstream value chain of basic materials. Therefore, only one design needs to be considered in this assessment.

As described above, the estimation of compliance costs for an excise duty assumes cost elements similar to existing excise duties. Detailed data on the compliance costs for excise duty obligations is available for German excise duties on tobacco, different types of alcohol and coffee. Cost elements below are taken from the Destatis' OnDEA database and standardised using case numbers available on the platform[42].

2. 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 companies (SMEs). However, the evidence body in the literature is well developed both for the difference between large and smaller companies in administrative burden of tax or customs measures as well as 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 on the case of valued

[41] Unit differs between third-country installations for MRV and inspection costs, and importers for documentation and surrender of CBAM certificates.

[42] Destatis OnDEA database: https://www.ondea.de/DE/Home/home_node.html.

added tax (VAT), Barbone et al. (2012) present a similar finding in the context of a review of research papers. These finding is also confirmed by a study conducted by KPMG and GfK on behalf of the European Commission[43]. 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 in a high-level analysis. In a South African study, Smulders et al. (2012) still finds substantially lower compliance costs for customs and excise duties than for VAT or CIT. Recording of information is also found to be a main factor in this study, behind the familiarization with the tax instrument.

Literature sources on the compliance costs with carbon quantification instruments point in a similar direction. Academic work finds substantially higher administrative costs per tonne of CO_2 for small emitters in emission quantification systems like the EU ETS[44] 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 more than 8 times higher compliance costs 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[45] 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 considered raw materials[46]. The fact that a CBAM applies to imports of a few basic materials and basic material products results in large businesses being the main mainly impacted ones. 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 compared on the amount imported.

[43] KPMG & GfK. (2018). Study on tax compliance costs for SMEs. EASME/COSME/2015/004. Brussels. European Commission. https://op.europa.eu/en/publication-detail/-/publication/0ed32649-fe8e-11e8-a96d-01aa75ed71a1

[44] Coria, J. & Jaraite, J. (2019). Transaction Costs of Upstream Versus Downstream Pricing of CO_2 Emissions. Environmental and Resource Economics, 72(4), pp. 965-1001.

[45] See https://ec.europa.eu/eurostat/databrowser/view/SBS_SC_IND_R2__custom_553424/default/table?lang=en

[46] EU-MERCI. Analysis of the industrial sectors in the European Union. http://www.eumerci-portal.eu/documents/20182/38527/0+-+EU.pdf

An option that includes goods further along the value chain, or also EU internal transactions like the proposed excise duty option, would result in a higher 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[47] which applies to EU manufacturers and importers highlights the higher burden for SMEs, compared to large companies[48]. The quantification of this effect for the CBAM is however not possible at this point as available data is lacking.

3. 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 controlling the reports from economic operators. Literature describes the same cost drivers for administration and enforcement costs as for compliance for taxation measures (Barbone et al., 2012). This is most importantly the complexity 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 authorities.

As authorities are already assessing customs declarations for imported goods in the volume and scope of this study, an existing infrastructure and processes are in place. This assessment of enforcement costs will again provide estimations on the additional costs compared to this 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 assessed administration and compliance costs. In line with the compliance cost assessment, the estimations are based on studies published by the European Commission[49] as well as impact assessments at EU and national levels[50]. In cases where the enforcement effort was indicated in a time duration, the average hourly wage costs of the EU[51] were used to estimate the resulting costs.

IT infrastructure

An overarching cost element is to have the necessary IT technology in place. Collected data 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 goods to CBAM certificates either already surrendered at that point or to be surrendered

[47] Regulation on the registration, evaluation, authorisation and restriction of chemicals. EC Regulation No 1907/2006.
[48] See also SWD (2018) 58 final.
[49] 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 .
[50] Impact assessment of EU customs and tax instruments, the implementation of EU legislation in Germany, and of taxation initiatives in the UK.
[51] https://ec.europa.eu/eurostat/statistics-explained/index.php/Wages_and_labour_costs

(also if applicable[52]). In any case, data on the imported quantities and related pricing of the CBAM certificates 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 the CBAM as an excise duty as this would also require an interface between Member States and the EU Commission, including the customs organisations.

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[53]. Across the options assessed below, the need for additional IT systems varies slightly depending on their complexity and need for collaboration but additional infrastructure would in all cases be necessary to process the data and share it between customs and CBAM authorities.

Similarly 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[54] 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, the process of 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.

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 Member State for a decentralised IT system, the currently launching Single Window Environment can 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 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[55]. 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 this number.

[52] See subsequent sections for the costs of the different set-ups

[53] Deloitte (2016). VAT Aspects of cross-border ecommerce - Options for modernization. Final report – Lot 3: Assessment of the implementation of the 2015 place of supply rules and the Mini-One Stop Shop. Brussels. European Commission. https://ec.europa.eu/taxation_customs/sites/taxation/files/vat_aspects_cross-border_e-commerce_final_report_lot3.pdf .

[54] See: https://ec.europa.eu/taxation_customs/general-information-customs/electronic-customs/eu-single-window-environment-for-customs_en .

[55] 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

Import tax

For CBAM options using an import tax, efforts are necessary for processing documents, administering payments and controlling the correct declaration of goods. In the case of actual emissions that are reported, these reports and validations would need to be assessed as well. Except for the last cost element, customs authorities are already performing these tasks. A CBAM that fully relies on default values would be based for very large parts 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 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 goods 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 based on the standardised estimations of costs for additional controls to enforce the import elements of the VAT obligations of e-commerce[56].

In comparison, an import tax with the option or even expectation to present actual emission values has a higher complexity and creates higher costs for enforcement. The processing of customs declaration would require more time, as the existence of an emissions report supporting the declared carbon content would need to be checked. The CBAM obligation would need to be paid based on the declared emissions at the time of import. Together with the necessary controls, 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 need to be assessed. As the reporting needs 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[57], this results in costs of EUR 6 750 per installation from which goods are imported. 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 the refunding in case the actual emissions were lower creates costs that do not arise when using default values. Using the administration of EU ETS accounts as a proxy[58], this element is estimated at EUR 400 per importer per year. In addition to this, it is assumed that a small amount of site inspections at production sites would be carried out to verify compliance also at the level of production process. As

[56] 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.
[57] 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
[58] Amec Foster Wheeler Environment, 2016.

this is assumed to target only a sample every year, the costs are estimated at EUR 351 per installation per year[59].

Table 6-4 summarises the ongoing administration and enforcement costs for CBAM options based on an import tax. To these, the costs for setting up and maintaining the IT infrastructure need to be added.

Table 6-4: Yearly administration and enforcement costs for an import tax-based CBAM in EUR

Costs / Cost element	Unit costs[60]		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**	**9 315 000**	**14 026 510**

Sources: Amec Foster Wheeler Environment, 2016; German Parliament, 2020.

Import certificates

The administration and enforcement costs for the implementation of the CBAM using import certificates are structured very similarly to the import tax option described just above. The main difference is the greater involvement of an authority responsible for issuing and administering the surrender of the certificates. 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 to this, a set-up similar to the EU ETS with national competent authorities is also conceivable. This is expected to result in substantially higher costs due to the stronger need for collaboration and coordination relating to the assessment of monitoring and verification.

---

59 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.

60 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.

As the CBAM based on import certificates would also be calculated at the point of import, customs authorities will need to collect and, depending on the roles given to either customs authorities and the CBAM Authority/national authorities, process the information related to the imported product. Data necessary to calculate the amount of CBAM certificates to be surrendered would have to be included in the customs declaration and either certificates will be directly surrendered or added up for a final balance for a full calendar year. While customs will always have an important role, the option of requiring a surrender or proof of surrender of the certificates at the time of import will have a significantly higher impact on customs costs. If customs authorities only collect this information on behalf of the CBAM authority/national authorities, which would perform the yearly balance, reconciliation and ensure submission, the costs for customs authorities are lower, as those costs would be shifted to the CBAM authority/national authorities. The costs would arise in both cases, either for customs authorities or for the CBAM authority/national authorities, and are for this assessment assumed to be similar.

In the scenario where default values are used to calculate the certificates 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 based on the assessment of such costs for the national implementation of the EU ETS in Germany[61]. Because of higher 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 importer account are assumed for the administration of accounts and payments such as the supervision of the surrender of certificates. Additional customs controls are estimated similarly to the costs for the import tax.

As mentioned above for both compliance costs for industry and for enforcement costs of the import tax, the possibility to provide actual emissions as 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 before the customs authorities. Similar to the import tax, the monitoring reports and verifications need to be assessed by a responsible authority, for example the CBAM authority or in case of a decentralised system the national authorities. The costs for this are – just as for the import tax above – estimated at EUR 6 750 per report. This cost element would increase in the case of decentralised assessment of the MRV documents. In this case, authorities of multiple Member States would have to assess the documents of an installation unless a system of information, exchange and eventually acceptance of a decision taken in one Member States is put in place. In addition, the same costs for site visits are as for the import tax are assumed, adding on average EUR 351 per installation.

[61] German Parliament, 2020: 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

Table 6-5 summarises the administration and enforcement costs for CBAM options based on import certificates. To these, the costs for setting up and maintaining the IT infrastructure need to be added.

Table 6-5: Yearly administration and enforcement costs for an import certificates - based CBAM in EUR.

Costs / Cost element	Unit costs[62]		Overall costs	
	default factors	**actual emissions**	**default factors**	**actual emissions**
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, 2020.

Excise duty

As in the previous sections on practical implementation and the assessment of compliance costs, the option of implementing CBAM as an excise duty (Option 6) requires a different set-up of administration and enforcement. The implementation of an excise duty on carbon intensive material would be similar to existing excise duties. However, there are different configurations of excise duties that result in substantially differing enforcement requirements and costs for authorities.

Data sources for existing excise duties are scarce and not comprehensive in their assessment of different cost elements. The central element influencing the costs for enforcement of an excise duty 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 excise duties on highly taxed products like tobacco. The high costs – not only for authorities but also for economic operators – are mentioned

[62] 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.

by the experts. As the excise duty systems 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 duty requires processing data reported by businesses, maintain the data infrastructure, and monitor compliance through controls[63]. Important factors influencing the administration and enforcement costs are the complexity of products and the number of producers obliged to pay the excise duty. A higher number of producers increases costs for the authorities[64]. As discussed in the assessment of compliance costs for businesses, the number of producers will be high compared to other excisable goods, because of the nature of the covered products as basic materials for many value chains.

Because of the nature of product and the similarity in set-up, excise duties or consumption charges for plastic 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 and Spain as well as in the 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[65]. 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 that. With the available evidence base, a more precise quantification is difficult to achieve.

Comparison with EU ETS

Under **options 2, 3, 4 and 5**, and while the import certificates options would differ in comparison to the EU ETS (as the system for import certificates would cover goods and not stationary installations, would involve third party verification, foresees an assessment based on declared emissions, covers less goods, etc.), the administrative costs of the current EU ETS may provide an interesting point of comparison. Indeed, under these options, the setting up of a CBAM would need to consider selling the CBAM certificates (using EU ETS auctioning prices as a proxy), a CBAM registry (as mentioned above although simpler than the EU ETS registry) and Monitoring, Reporting and Verification systems for taking into account actual emissions. In the case of EU ETS:

- The auctioning platform costs around EUR 1.6 million per year, of which EUR 1.5 million is covered by fees for auctioning participants, and EUR 150 000 paid by the Commission (for reporting, etc.).
- About 2 full-time equivalent for auctioning in DG CLIMA.
- 24 full-time equivalent for handling the EU ETS Union Registry.

[63] 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.

[64] ECOTEC et al., 2001: Economic and Environmental Implications of the Use of Environmental Taxes and Charges in the European Union and its Member States

[65] Converted from GBP, https://www.gov.uk/government/publications/introduction-of-plastic-packaging-tax/plastic-packaging-tax.

- Around EUR 3–4 million for external contracts for the EU ETS Union Registry (IT development and maintenance, service desk, infrastructure/costs). IT development, procurement choices and potential inclusion of infrastructure costs in the H7 infrastructure budget via co-financing baselines will be subject to pre-approval by the European Commission Information Technology and Cybersecurity Board
- For Member States (not taking into account the costs related to free allocation as there will be no equivalent in CBAM): managing accounts, permitting, validation of data from operators: 1 – 100 full-time equivalent per Member State, with an average 15 full-time equivalent per Member State (in total around 400 full-time equivalent for EU-27). In case a CBAM centralises these functions, the amount of full-time equivalent needed strongly depends on the number of importers;
  Verifiers are paid by operators, around EUR 1 000 – 10 000 per year and per operator; National Accreditation Bodies (supervising verifiers): around 2 full-time equivalent per Member State. For a CBAM, there might be a limited need for additional staff.

4. Summary of the results of the costs 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, 2, 3, 4 and 5 could be implemented by obliging importers to either pay an import tax or to surrender import certificates (CBAM certificates). It should however be noted that the assessed options differ in key underlying features such as the covered value chain, which impacts the direct comparability of the options.

An import tax relying on default values would be an option resulting in comparatively low costs. 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 an import certificates option.

A CBAM with the possibility to demonstrate actual emissions 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 and import tax or between EUR 9.8 million and EUR 14.3 million for import certificates.

Moreover, the further depth of the value chain adds more relevant installations, importers, and import transactions. This increases the compliance costs compared to similar designs only targeting basic materials (and basic material products). The introduction of an excise duty, 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.

Table 6-6: Estimated total compliance costs for businesses in EUR.

Specifications	Import tax	Import certificates	Excise duty

Default values	5.4 million	5.44–6.9 million	N/A
Actual emissions	18.84–26.98 million	18.88–28.48 million	N/A
Excise duty	N/A	N/A	23.1–45.1 million

Source: Previous calculations

Considering the volumes of imports of all sectors considered in this study, the compliance cost per tonne of import or per tonne covered by the excise duty system would be very low for import mechanisms using default values or an excise duty-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 Eurocents per tonne. Table 6-7:summarises these results.

Table 6-7: Compliance cost of CBAM per tonne of import (in EUR).

Specifications	**Import tax in EUR**	**Import certificates in EUR**	**Excise duty in EUR**
	per tonne imported	**per tonne imported**	**per tonne covered by the excise duty system**[66]
Default values	0.071	0.071–0.090	N/A
Actual emissions	0.110–0.353	0.111–0.373	N/A
Excise duty	N/A	N/A	0.043–0.085

Sources: previous calculations, industry data, Eurostat[67]

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 import certificates (CBAM certificates), the import charge creates marginally lower compliance costs. This is because of the easier integration in existing obligations.

Enforcement costs for authorities are driven by similar factors as are compliance costs for businesses. The higher the complexity of the system the higher the costs of enforcement. For this reason, a CBAM using only default values creates lower costs as options using more accurate emission as reported by importers based on the monitoring in the production sites. For all options, compliance controls by customs make up a major share of the costs. In addition, the set-up of an IT system to collect and exchange data between

[66] Including both EU production and imports of the covered sectors.
[67] See: 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

the responsible authorities adds another important share of the costs. These depend on the implementation in a centralized (with possibility to be included in the Single Window Environment for Customs), or in a decentralized way. The latter is expected to create substantially higher costs than the former.

The options of import tax and import certificates 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 import certificates requires an authority to sell CBAM certificates and monitor the 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 incur in the CBAM authority/national authorities rather than in customs authorities.

The implementation in co-existence with free allowance allocation under the EU ETS would result in similar costs for authorities as an import tax or import certificates with full auctioning, 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 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 large shares 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.

An excise duty differs from the border instruments mentioned in the previous paragraphs. Because of less data 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 duty 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 6-8: summarises the estimations for enforcement costs for the different options.

Table 6-8: Estimated total enforcement costs for authorities in EUR

Specifications	Import tax	Import certificates	Excise duty
Default values	9.3 million	10.3 million	N/A
Actual emissions	14 million	15 million	N/A

Excise duty	N/A	N/A	>12.9 million

Source: Previous calculations, industry data, Eurostat[68]

[68]See: 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

ANNEX 7: SELECTION OF SECTORS

This Annex describes the issue of scope 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.

1. Overview

Several principle dimensions have to be discussed regarding a feasible scope of a carbon border adjustment mechanism:

(A) The industry sectors affected, using a suitable classification such as NACE.

(B) How far down the value chain the CBAM should be applied (whether only basic materials or more complex goods should be covered, see section 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 goods which are identifiable in terms of product codes used in international trade, such as the CN (Combined Nomenclature) system.

All of these aspects are discussed in the report, although the focus is on points (A) and (B). 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'. Options to define embedded emissions have an inevitable link to the necessary MRV system, which in turn have strong impacts on the technical and administrative feasibility of the CBAM. Aspect (B) therefore has to be assessed in strong connection with those design elements. Section 4 will specifically discuss the impact of practical feasibility aspects on the selection of sectors/products.

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 focusses 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 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 if 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 GHG, and whether there is an emission reduction potential), which for the purpose of this study and in line with the EU ETS' design[69] 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 for being covered by the EU ETS, the sector does not face emission costs and is per 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***[70]: 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 only few[71] Member States apply the indirect cost compensation. Therefore, we use as an indicator whether a sector should be covered by this criterion, whether the EU State Aid Guidelines for indirect EU ETS cost compensation[72] 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 goods 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 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

[69] Note that other classification 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 aren't suitable.

[70] 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.

[71] 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.

[72] 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.

material products'. 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.b to 4.d approach this topic. The value chain issue is also firmly linked to the options chosen for defining embedded emissions and impact the administrative burden via the MRV system required.

- **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 6 are drawn on our judgment **that it will be feasible to define reference values for the embedded emissions** as the decisive argument for a product or material's inclusion in the CBAM. Without such reference values it is impossible to calculate the CBAM obligation to be paid upon import.
  - Furthermore, the choice of the scope will require certain design choices on other elements (it is e.g. useless to demand 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). 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.
- The width of the CBAM 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. However, for selecting sectors we consider the revenues not as a primary criterion in this report. They would be a secondary and ancillary positive effect of the design. We will therefore not use it as 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. It would therefore not be appropriate to assess this topic in isolation based on only the materials and goods in the CBAM scope.

3. Starting point: Industry sectors

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

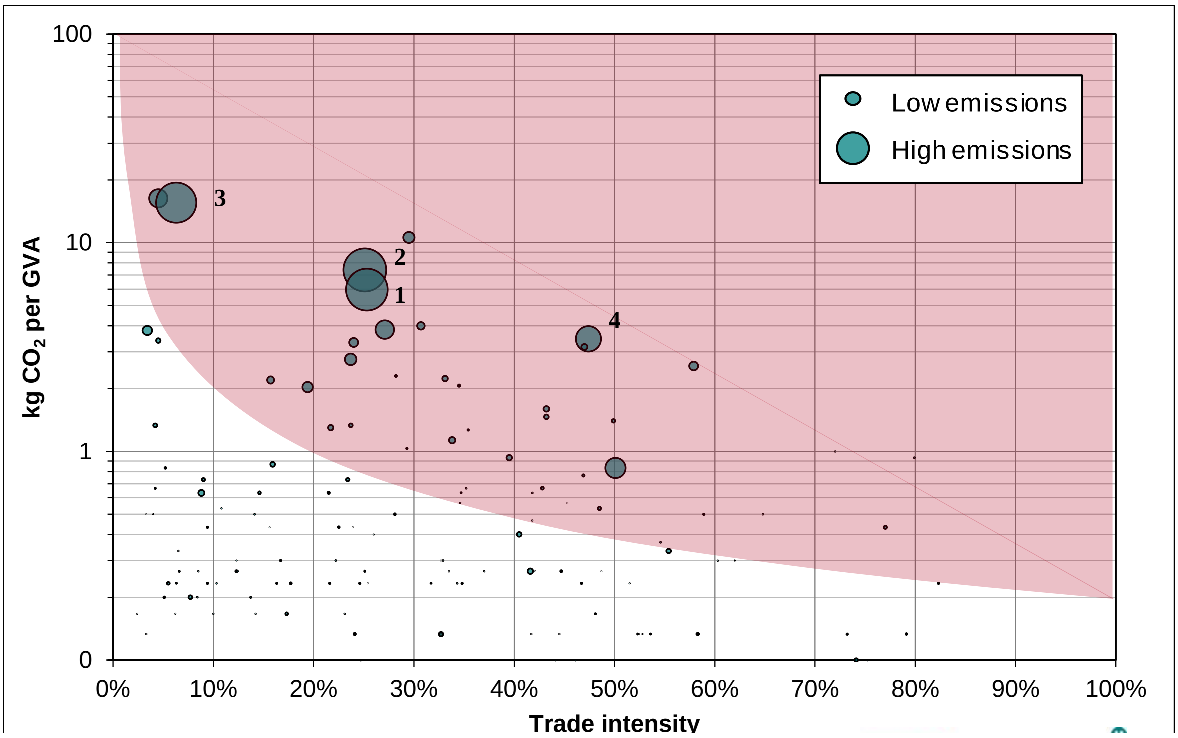
For successfully implementing a CBAM, those 63 sectors and the multitude of products and materials produced by them might be too difficult to regulate. It is proposed to focus on fewer sectors, at least for a pilot phase. This would make the CBAM simpler and more manageable.

Figure 7-1 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 at relatively low administrative effort. In particular, this would allow 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 literature.

Moreover, the discussion of MRV systems and the possibilities to define the 'embedded emissions' of goods 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 to 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 considers that theoretically all goods 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 7-1: Position of NACE sectors regarding the CL criteria for the 4th EU ETS phase. 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.



Source: Commission Analysis

b. Proposed aggregated sectors for further discussion

The CLL contains 50 sectors at 4-digit NACE level and further 13 sectors at more disaggregated level (6 or 8 digit PRODCOM). For making the discussion about sectors easier to handle, 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[73] (CLL) for the 4th phase of the EU ETS and for which installations are currently found in the EU ETS[74]. This aggregation is given in Table 7-1: at the end of this Annex, 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,

[73] 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.
[74] Note that numbers in this section include installations from the EU-27, the UK as well as the EFTA countries Norway, Iceland and Liechtenstein.

Table 7-3, 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 → Vinyl chloride monomer (VCM) → S-PVC; or in the fertiliser sector: Ammonia → nitric acid or urea → various Nitrogen-Phosphorus-Potassium (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 the attributing of emission data to products in the MRV system would be too complex to determine benchmarks. Those are aggregated in the category 'other sectors[75]', which together account for about 10 % of the CL exposed EU ETS emissions. The result of this exercise is presented in Figure 7-2 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 and 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.

Figure 7-2: Proposed aggregated sectors sorted by emissions.

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%

Source: Commission analysis

[75] We have aggregated here some sectors with product benchmarks but low emissions: Coke and 'other mineral products' (including 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.

If 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 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 CLL. However, in the administration of EU customs and taxes, CN[76] 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) Harmonized System (HS) classification developed under the UN. CN codes cover more commodities than PRODCOM[77]. 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[78]. A final choice of the most useful classification system will only have to be made when a CBAM will be finally defined in a legal instrument.

The identified aggregated sectors build the starting point for further discussion in the next 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 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 the custom offices decisions and calculation of the CBAM obligation needs to be made based on the type of product. Therefore section c first outlines some consideration on how products can be defined. Thereafter the central question is discussed, namely for which products the embedded emissions can be determined. For this purpose, a discussion of the most important value chains in the EU ETS sectors is given in section 4.c.

c. 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[79] under the CBAM can be determined by the designated authority. For this purpose it is not enough to clarify only the (carbon leakage exposed) sector using a NACE or PRODCOM code like in the Carbon Leakage List, but to list specifically all the products from within 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

[76] Combined Nomenclature, which is the European statistical classification system compatible with the United Nation's HS (Harmonized System) used in international trade.
[77] E.g., since 2005 PRODCOM does not contain codes for refinery products such as gasoline, diesel and kerosene.
[78] E.g. for CN 2019 and PRODCOM 2019: http://ec.europa.eu/eurostat/ramon/documents/prodcom_2019/PRODCOM_2019_CN_2019_mapping.zip
[79] I.e. the amount of tax to be paid, the emission data to be declared or the number of CBAM certificates to be surrendered.

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 defined by specifying their PRODCOM codes or better: CN codes, together with the applicable default reference values for the embedded emissions required for defining the amount of obligation under the CBAM, if not the actual emissions option is at hand.

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 invite for 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 appealing for importers to claim their product to be 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, 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 the designated authorities together with reference data for selected tracer elements which would allow identifying 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 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, already now sufficient instruments exist, since all kinds of custom tariffs need to be confirmed in practice, too.

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**. This question is intertwined with the design of the MRV system and the approach chosen for determining default values. However, as will be discussed there, a solution will almost always be possible if the system boundaries of MRV are chosen reasonably. In order to understand what kind of ‘reasonable’ would be meant here, we will discuss in the next section what kind of value chains have to be considered in context of the EU ETS and CBAM.

4. **Practical 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[80]. 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 in particular important, as in case 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.

a. Overview

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 literature and by stakeholders from different industry sectors. In order to provide as unambiguous information as possible in this report, there is reference to the definitions found in Annex 5. We use a very pragmatic approach instead of an

[80] Böhringer, C., Rosendahl, K. E., & Storrosten, H. B., 'Robust policies to mitigate carbon leakage', *Journal of Public Economics* 149, 2017, 35-46 https://doi.org/10.1016/j.jpubeco.2017.03.006; Cosbey, A., Droege, S., Fischer, C., & Munnings, C., 'Developing Guidance for Implementing Border Carbon Adjustments: Lessons, Cautions, and Research Needs from the Literature', *Review of Environmental Economics and Policy*, 13(1), 2019, 3–22. https://doi.org/10.1093/reep/rey020; Flannery, B., Hillman, J., Mares, J. W., & Porterfield, M., 'Framework Proposal for a US Upstream Greenhouse Gas Tax with WTO-Compliant Border Adjustments', *Resources for the Future*, 2018; Kortum, S., & Weisbach, D. J., 'The Design of Border Adjustments for Carbon Prices', *National Tax Journal*, 70(2), 2017, 421–446. https://doi.org/10.17310/ntj.2017.2.07; Das, K., 'Can Border Adjustments Be WTO-Legal?', *Manchester Journal of International Economic Law*, 8(3), 2011, 65–97; Mehling, M. A., van Asselt, H., Das, K., Droege, S., & Verkuijl, C.. 'Designing Border Carbon Adjustments for Enhanced Climate Action',*American Journal of International Law*, 113(3), 2019, pp.433–481. https://doi.org/10.1017/ajil.2019.22; Sandbag, 'The A-B-C Of BCAs', 2019. https://ember-climate.org/wp-content/uploads/2019/12/2019-SB-Border-Adjustments_DIGI-1.pdf; Branger, F., & Quirion, P., 'Would border carbon adjustments prevent carbon leakage and heavy industry competitiveness losses? Insights from a meta-analysis of recent economic studies', *Ecological Economics*, Vol 99, 2014, pp.29–39. https://doi.org/10.1016/j.ecolecon.2013.12.010; Böhringer, C., Balistreri, E. J., & Rutherford, T. F., 'The role of border carbon adjustment in unilateral climate policy: Overview of an Energy Modeling Forum study (EMF 29', *Energy Economic, 34, 2012,* S97–S110. https://doi.org/10.1016/j.eneco.2012.10.003.

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.

From the definitions above it becomes clear that 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 to bring together a multitude of basic materials and semi-finished products from various other sectors. Literature about CBAM often uses terms like the above without further definition. It is therefore often not clear on 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 for implementing a CBAM provides clear definitions of the products to be included, or at least clear criteria based on which some implementing acts can later define the precise definitions. Due to the mentioned complexities 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.

b. 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 3) there are 144 PRODCOM categories (including alloyed steels and ferroalloys 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[81] 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 basis for the definition of reference values. For basic materials coming directly out of an installation which 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 4th 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 e.g. 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[82]. On the other hand, for complex structures, extensive machining may be required, such that e.g. 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 4 times higher based on the mass of the product than for the original steel material[83]. Furthermore, most manufactured products

---

[81] Cosbey, A., Droege, S., Fischer, C., & Munnings, C., 'Developing Guidance for Implementing Border Carbon Adjustments: Lessons, Cautions, and Research Needs from the Literature', *Review of Environmental Economics and Policy*, 13(1), 2019, 3–22. https://doi.org/10.1093/reep/rey020; Mehling, M. A., van Asselt, H., Das, K., Droege, S., & Verkuijl, C., 'Designing Border Carbon Adjustments for Enhanced Climate Action', *American Journal of International Law*, 113(3), 2019, pp.433–481. https://doi.org/10.1017/ajil.2019.22; Monjon, S., & Quirion, P., 'How to design a border adjustment for the European Union Emissions Trading System?', *Energy Policy*, 38(9), 2010, 5199–5207; Droege, S., *Tackling Leakage in a World of Unequal Carbon Prices*, 2019, http://www2.centre-cired.fr/IMG/pdf/cs_tackling_leakage_report_final.pdf; Sakai, M., & Barrett, J., 'Border carbon adjustments: Addressing emissions embodied in trade', *Energy Policy*, 92, 2016 102–110. https://doi.org/10.1016/j.enpol.2016.01.038; Gisselman, F., & Eriksson, E., 'Border Carbon Adjustments. An analysis of trade related aspects and the way forward', *National Board of Trade Sweden*, 2020 https://www.kommerskollegium.se/contentassets/7a09d4cdb83a46feaf0c6ae6e5b02fff/border-carbon-adjustments_final_.pdf; Böhringer, C., Carbone, J. C., & Rutherford, T. F., 'Embodied Carbon Tariffs', *The Scandinavian Journal of Economics*, 120(1), 2018, pp.183–210. https://doi.org/10.1111/sjoe.12211; Pauliuk, S., Neuhoff, K., Owen, A., & Wood, R., 'Quantifying Impacts of Consumption Based Charge for Carbon Intensive Materials on Products', *DIW Discussion Papers No. 1570*, 2016. http://www.ssrn.com/abstract=2779451

[82] 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.

[83] 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 should be kept reasonable, it would be easier to fully assign all 100% steel emissions to

(for end consumers) consist of far more than two basic materials and require many production steps[84], 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 goods 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[85] product' itself is a good for purchase by an end consumer. This is the case e.g. 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 homogeneous appearing materials are in fact complex mixtures (e.g. PVC contains significant mass fractions of stabilizers, plasticizers 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 wires etc. is several orders of magnitude lower than the final product's. 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:

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

However, at least for those options which are import-oriented, 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. 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

---

the product under consideration, while the emissions of recycling would be fully attributed to the EAF steel which used the scrap as input.

[84] 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, often there are 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.

[85] Energy Intensive and Trade Exposed.

therefore needs to discuss if that would be possible at reasonable administrative effort. This is done by discussing the most important value chains in the EU ETS in the next section.

c. *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 it is to be examined how 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, literature[86] 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 should be put on equal footing with imported goods regarding embedded carbon costs, it is necessary to look 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 high 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 described simplified 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

[86] Cosbey, A., Droege, S., Fischer, C., Reinaud, J., Stephenson, J., Weischer, L. and Wooders, P., ' A Guide For The Concerned: Guidance On The Elaboration And Implementation Of Border Carbon Adjustment', *Entwined*, 2012, https://www.iisd.org/system/files/publications/bca_guidance.pdf; Mehling, M. A., van Asselt, H., Das, K., Droege, S., & Verkuijl, C.. 'Designing Border Carbon Adjustments for Enhanced Climate Action',*American Journal of International Law*, 113(3), 2019, pp.433–481. https://doi.org/10.1017/ajil.2019.22; Pauliuk, S., Neuhoff, K., Owen, A., & Wood, R., 'Quantifying Impacts of Consumption Based Charge for Carbon Intensive Materials on Products', *DIW Discussion Papers No. 1570*, 2016. http://www.ssrn.com/abstract=2779451; Böhringer, C., Carbone, J. C., & Rutherford, T. F., 'Embodied Carbon Tariffs', *The Scandinavian Journal of Economics*, 120(1), 2018, pp.183–210. https://doi.org/10.1111/sjoe.12211; Moran, D., Hasanbeigi, A., & Springer, C., 'The carbon loophole in climate policy. Quantifying the Embodied Carbon in Traded Products' *KGM & Associates, Global Efficiency Intelligence, Climate Work Foundations*, 2018.

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 (fall-back 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 high 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 different benchmarks for both production routes have been introduced. The reason is due to the lower purity of scrap-based steels[87]. 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 3.c).

- 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: N-P-K). 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:
  - As a first step, ammonia is produced where natural gas is almost the exclusive raw material[88]. A dedicated EU ETS benchmark exists.

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

[88] 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 other substances than ammonia are produced. It is worth to mention that the vast majority of hydrogen is currently produced from natural gas, and only in 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 the ammonia production.

- 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 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[89].

- 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 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 produced polymer), one of the most complex value chains in the EU ETS can be construed:
  - The starting point are light fractions of the refinery products. Hence, some emissions based on the refinery benchmark[90] should be taken into account.
  - Production of simple olefins (ethylene, propylene, etc.) is usually using steam cracking. The EU ETS benchmark for HVC ('High Value Chemicals[91]') 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[92].
  - 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

[89] 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.

[90] 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.

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

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

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 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.

d. Feasibility to determine embedded emissions of basic materials

As said 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[93]):

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. 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 it would be reduced to only $EE_P = EM_P$. For applying it 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 applying MC_i values which take into account how much of the upstream produced materials pass through the value chain to give the product or material under consideration.

From that 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:

[93] As this here is only about the purely technical arguments and description of the important value chains, there is no need to take carbon costs into account.

- 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 goods. For those basic materials which are covered by EU ETS product benchmarks, the FAR[94] provide relatively clear rules for defining system boundaries (so-called sub-installations), and for attributing Combined Heat and Power (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 fall-back 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[95]' 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 to attribute 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

[94] 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.
[95] 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.

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 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 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.
  - 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[96].
  - 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.

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

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, a higher level of precision and robustness against potential legal challenges will be required. The preferred approach for solving such issues 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.

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 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 to the installations covered, which often produce a multitude of different products. However, when an imported good is to be subject of 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 certificates or a tax.

As has been raised in section 3.c, 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.

In that respect, adopting implementing acts could be used. Implementing acts could be further be used for defining other technical details such as specific monitoring procedures and actual default values for the embedded emissions of various products. Thus, technological progress and the development of new product groups, or the gradual introducing of products along the value chain when more data becomes available can be also envisaged.

Table 7-2 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 to what data is required and whether 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 to provide the basis for the decision if the material or product can be included in the CBAM.

Larger groups of CN/HS codes have been gathered into material and product groups for the purpose of Table 7-2. The materials/products are named in the first column of that table**.**

Materials and products are considered to be within the same group where production processes suggest that the level of embedded emissions (EE_P) as 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 sufficiently on a 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 6), EE_P levels don't have to be perfectly exact, as they would not have to fully relate to true 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 7-2: Material and product categories, data requirements and considerations for inclusion in the CBAM, for selected aggregated sectors.

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 and 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; Don't include product in CBAM, as imports are negligible
Ferro-Alloys			No (tbd)	Too diverse products, no EU ETS product benchmark (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 and 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 and further	'Hot metal' (EU ETS	*MCi* of hot metal (or estimate as 100%),	possible	Promising candidate (often mentioned in literature). Proposal here to include also

CBAM Product name	Precursors	Data needs	Include in CBAM?	Other comments
steps	BM) / iron and steel in primary forms	EE_P for 'hot metal'; correction factor for hot rolling (based on fuel input, not available from EU ETS data)		cold-rolled products (which includes a step after hot rolling)
Coated hot rolled and further steps	Hot rolled steel	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 big.
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 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
Iron and 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

CBAM Product name	Precursors	Data needs	Include in CBAM?	Other comments
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 and 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 unwrought		EU ETS data and data on indirect emissions (State aid Guidelines)	yes (tbd)	Discussion regarding electricity mix and resource shuffling likely. However, product is reasonably homogeneous. Problem to distinguish primary and secondary aluminium.
Aluminium unwrought 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 and 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)
Paper	pulp		no	Identification of products seems possible. However, Limited CL impact (see pulp), determination of EE_P difficult.

CBAM Product name	Precursors	Data needs	Include in CBAM?	Other comments
Fertilisers (HS 31)				
Ammonia		EU ETS data and data on indirect emissions (State aid Guidelines)	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 and 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 don't 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
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 sulphate 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	Possible	Relatively simple product definition (basic

CBAM Product name	Precursors	Data needs	Include in CBAM?	Other comments
		ash production.		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. Precondition is that an EE_P value for naphtha production can be determined.	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 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 don't 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

CBAM Product name	Precursors	Data needs	Include in CBAM?	Other comments
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 on the long run to define proxy values for EE_P. However, based on experience from the EU ETS benchmarking exercise, it is 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 big 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 (Poly-propylene)	Propylene (see HVC)	*MCi* and EE_P of Propylene required	possible	Inclusion in CBAM depends on data availability, but makes sense due to the big amounts produced and traded. For a better EE_P value, additional emission data (covering the polymerisation process) would be required.
PVC (Poly-vinyl-chloride)	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 big 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 (Polyethylene terephthalate)	Tereph-thalic 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

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. In all cases the carbon intensity of sectors and their trade intensity are an important selection factor. Moreover, 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 warrant to consider also 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 a default value only on imported goods, while maintaining actual values on emissions intensity within the EU

ETS will require default values which are established in a way that is compliant with international rules.

Table 7-3: Supplementing Tables for Annex 7 on sectoral scope of CBAM

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2/yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[97]	Remarks
Iron and Steel	24.10	Manufacture of basic iron and steel and of ferro-alloys	396	156 358	97	Hot metal EAF carbon steel	Basic oxygen steel EAF carbon steel	Benchmarks in brackets may need to be considered for value chain purposes
	24.20	Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	32	1 304	31	EAF high alloy steel Iron casting (sintered ore)	EAF high alloy steel FeSi FeMn	Fall-back approaches for hot rolling and several other processes etc.
	24.51	Casting of iron	28	1 705	15	(Coke)	SiMn	
	25.50	Forging, pressing, stamping and roll-forming of metal; powder metallurgy	29	495	1*	Fall-backs		
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 Fall-back 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		Fall-back approaches relevant e.g. for heat imports and exports.

[97] 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[97]	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 not eligible in 4th phase anymore. 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 fall-back 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 (not eligible in 4th phase anymore)	
Pulp and Paper	17.11	Manufacture of pulp	56	1 722	4	Short fibre kraft pulp		Several products outside the BM

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2/yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[97]	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		definition, hence fall-back approaches relevant.
Lime and 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 fall-back 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 Hydrogen	Carbon black Chlorine (not in EU ETS)	Very high number of very different processes and products, high number of application of fall-back 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).
	20.13	Manufacture of other inorganic basic chemicals	113	16 045	105	Soda ash (Refinery Products) Fall-backs	Si metal hyperpure polysilicon SiC (Silicon Carbide)	

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2/yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[97]	Remarks
Food and 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 coloured glass Continuous filament glass fibre products Mineral wool Fall-backs		Many products outside the BM definition, hence fall-back approaches relevant. Proposal: Include 'mineral wool' here instead of under 'other mineral products'
	23.13	Manufacture of hollow glass	197	10 684	18			
	23.14	Manufacture of glass fibres	45	1 149	8			
	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)	Fall-back 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		Many products outside the BM definition (in particular 'normal

Short sector name	**NACE**	**Sector description**	**# of inst.**	**Emissions [kt CO_2/yr]**	**# of PROD-COM**	**Applicable Benchmarks**	**Indirect cost compensation benchmarks[97]**	**Remarks**
	23.31	Manufacture of ceramic tiles and flags	303	6 829	1	Pavers Roof tiles Spray dried powder Fall-backs		building bricks', tiles, table and sanitary ware, etc., hence fall-back approaches relevant.
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 E-PVC (Steam cracking, Vinyl chloride monomer, Adipic acid, Synthesis gas, Refinery Products) Fall-backs	(Chlorine, Steam cracking)	Potentially very high number of very different processes and products, high number of application of fall-back 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.
	20.17	Manufacture of synthetic rubber in primary forms	9	866	2			
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		

Short sector name	NACE	Sector description	# of inst.	Emissions [kt CO_2/yr]	# of PROD-COM	Applicable Benchmarks	Indirect cost compensation benchmarks[97]	Remarks
	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		
	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 CLL.

** Number of PRODCOM 2004 codes (no codes in current PRODCOM system); There are 46 corresponding CN codes.

ANNEX 8: CASE OF ELECTRICITY – IMPACTS

The PRIMES model, used for the purpose of simulating the application of the CBAM on electricity imports, shows that the impacts of the considered options on total carbon emissions reductions (in the EU and its neighbours) differ greatly.

Option A vs Option B

Under option A, there is no effect on total CO_2 emissions until 2025 and very little until 2030 (see figure 8.1). The environmental impact of this option is therefore very limited and significantly smaller than the impact of option B.

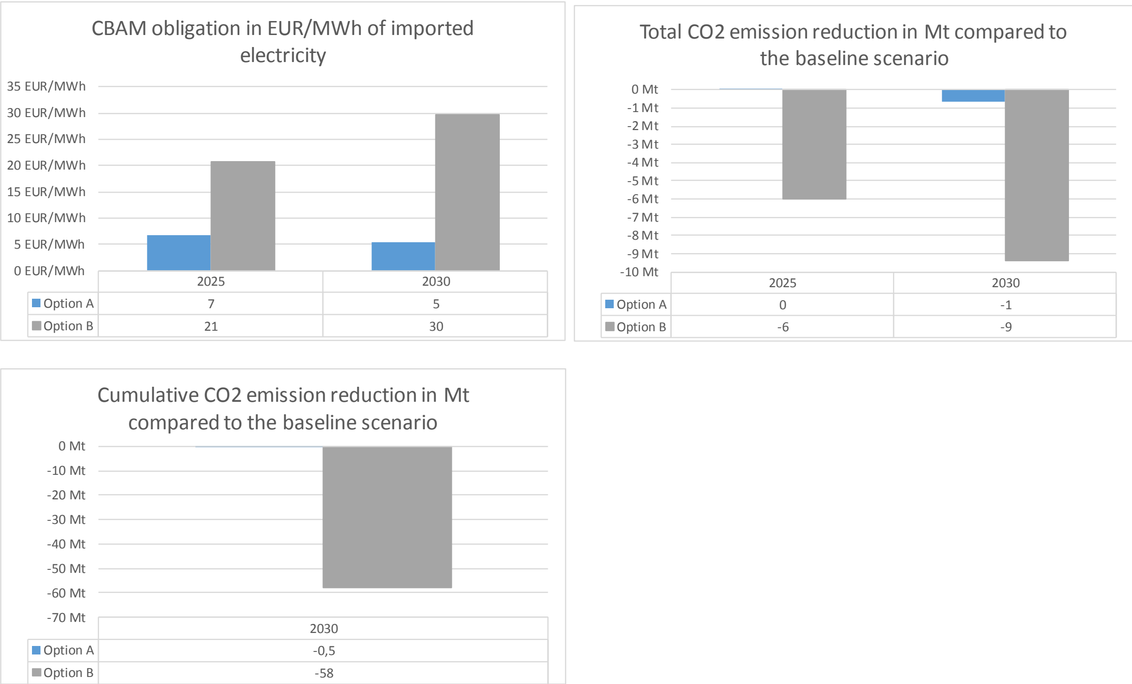
The large difference between the environmental impact of option B with regard to option A stems largely from the fact that option A results in a relatively low estimated CBAM obligation (5 €/MWh in 2030 compared to 20–30 €/MWh under option B in the same year) which is insufficient to meaningfully affect cross-border electricity trade and prevent carbon leakage.

Additionally, by exerting greater influence on trade patterns and by offering a degree of protection against carbon leakage, option B incentivises more efficient investment in new renewable capacities in certain Member States bordering third countries, which results in higher renewable generation within the EU replacing part of the discouraged imports. This represents another important channel through which CO_2 emissions are avoided, although its effect is much weaker under option A. Overall, option B displays superior effectiveness in preventing carbon leakage due to a greater amount of carbon-intensive imports, and hence generation, avoided.

The electricity mix within the EU does not change significantly due to the application of the CBAM in the sector. Given its very limited effects on cross-border trade, option A leaves the structure of power generation almost unchanged.

Option B therefore introduces a higher barrier for emission-intensive imports which requires increased generation in the EU as replacement. Since the additional generation is less emission-intensive, the overall effect on carbon emissions is positive. Consequently, option B is considered to be preferable to option A.

Figure 8-1: Scale of CBAM obligation by option and impact of CO_2 emission reduction (Options A and B)



Source: PRIMES

Analysis of the impact of the variants of option B

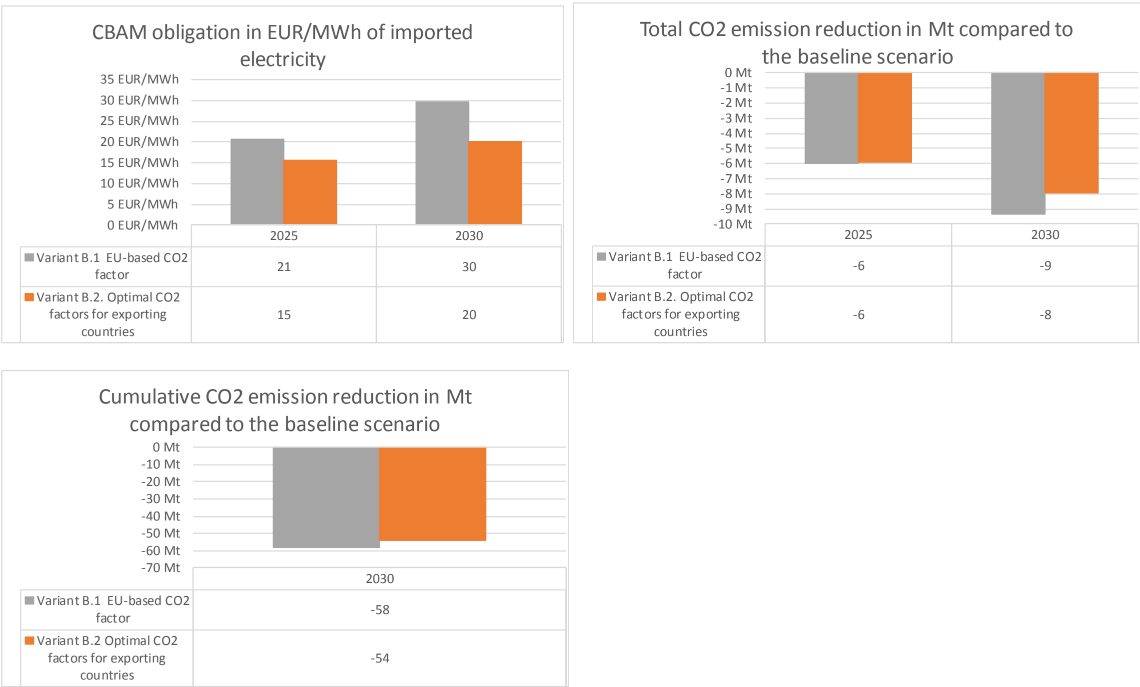
Variant B.1 and variant B.2 set the range of the CBAM obligation and therefore of the impacts of the variants under option B. From a situation where all exporting countries use EU CO_2 factor, to the most favourable situation for all exporting countries, to a situation in which exporting countries can choose the country CO_2 factor when lower than the EU CO_2 factor.

Option B reduces cumulative CO_2 emissions by 0.80 % (54–58 Mt CO_2[98]) by 2030, as can be observed in figure 8.3. Variant B.3's reduction of cumulative emissions is expected to be around the higher end of the latter interval[99]. Likewise, the environmental results for variant B.3 would be expected to fall close to the results for variant B.1.

[98] At the high end of the range (58 Mt CO_2) the EU benchmark is applied to the imports. At the low end of the range (54 Mt CO_2), importers optimise. Thus, the EU benchmark is not applied for imports from the countries where the CO_2 factor is lower than the EU CO_2 factor. The CBAM obligation is based on this mix of country CO_2 factors and the EU benchmark. For option A, little or no optimisation is assumed as the CBAM obligation is so low that it discourages importers to present evidence about the concrete carbon footprint of their product, which in the majority of cases is assumed to be higher than the benchmark.

[99] Under the assumption of a proportional distribution of electricity trade in 2030 as in 2019.

8-2: Scale of CBAM obligation by option and impact of CO_2 emission reduction (option B variants)



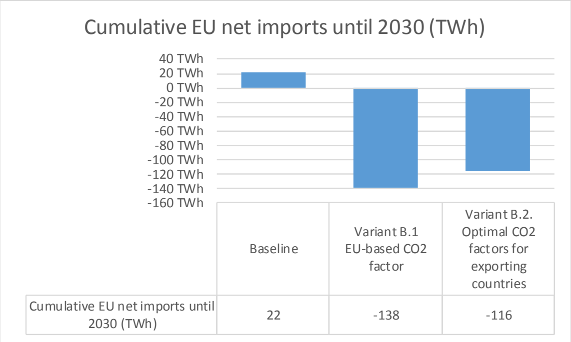
Source: PRIMES

In the range of variants under option B, which results in measurably lower imports, EU-based net generation rises by 0.50–0.60 % cumulatively until 2030, with the variant assuming no optimisation showing a larger increase. The additional power output is achieved thanks to higher renewable generation (mostly wind-based), which increases by 30–39 TWh in cumulatively by 2030, and by higher fossil-based generation, which increases by 110-123 TWh cumulatively until 2030. The overwhelming majority of the increase in the fossil fuel use in the EU comes from additional gas-fired generation, as coal-fired power plants lose competitiveness due to rising carbon prices. Thus, electricity imports from third countries, a significant part of which is sourced from coal-fired power plants, are predominantly replaced by gas-fired and renewable generation within the EU. CO_2 emissions in the EU increase due to higher fossil-based generation (by 1.00–1.10 % cumulatively until 2030, with the variant assuming no optimisation showing a larger increase), but this is more than compensated by lower CO_2 emissions outside the EU where the output of more carbon-intensive power plants is reduced. This ultimately results in lower CO_2 emissions globally and in reduced carbon leakage.

At EU level, the application of the CBAM causes cumulative net imports of electricity until 2030 to shift from 22 TWh in the baseline scenario to between -116 TWh and -138 TWh under option B (with the variant assuming no optimisation showing a larger difference [100]).

[100] Under option A, cumulative net imports of electricity until 2030 shifted to -10 TWh (meaning net exports). The CBAM has no noticeable effect on retail electricity prices at EU level in all options under consideration.

Figure 8-3: Impact on imports of electricity



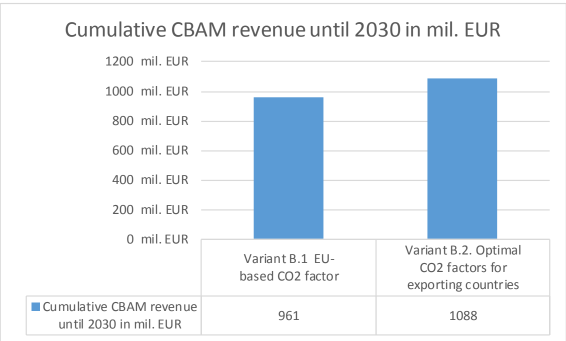
Source: PRIMES

From the system perspective, higher EU generation brings about greater generation costs which are, however, almost fully compensated by lower payments for electricity imports. The net result is a slight increase in EU system costs by 0.10 % under option B compared to the baseline scenario[101].

Under option B, the cumulative CBAM revenues reach between EUR 1.0–1.1 billion depending on the prevalence of optimisation. Within option B, the slightly lower revenue in the variant assuming no optimisation stems from the fact that the effect of higher CBAM obligation per MWh of electricity imported is overpowered by a rising volume of discouraged inflows from third countries, which ultimately reduces revenue. This variant thus represents the far end of the Laffer Curve[102].

In view of the relatively limited number of undertakings engaged in the business of importing electricity, the total administrative costs associated with compliance are expected to be low.

8-4: Impact on potential revenues



Source: PRIMES

---

101 Option A leaves system costs unchanged due to its lower effect on electricity trade. Revenues collected from CBAM obligations are not included in this calculation since they are expected to be recycled back into the economy (and they are too small to influence the system result anyway).

102 It should be noted that the cumulative CBAM revenues are similar between option A and option B. Under option A, they reach EUR 1.0 billion until 2030. A much smaller base for calculating the CBAM obligation in option A is compensated by higher import volumes which are subject to the measure and which have not been discouraged to the extent expected under option B.

Most preferred option

The modelling results point towards option B as the better option than option A since it delivers a better outcome in overall terms of environmental benefits, which are the overriding priority of the measure in question. While displaying superior qualities as far as preventing carbon leakage is concerned, option B and its variants also do not introduce sizeable additional system costs compared to option A. Variant B.3 appears the most preferred because it reflects better the specific country's carbon intensity of the exported electricity and introduces an incentive for countries to invest in a cleaner power mix.

ANNEX 9: ENERGY SYSTEM IMPACT OF AN IMPORT CBAM ON MATERIALS (IN THE FORM OF A NOTIONAL ETS BASED ON EXPORTING COUNTRIES' AVERAGE[103])

The current scope of CBAM focuses on energy intensive goods and its application has an impact on their production and price. This may have repercussions in the energy system. Current demand centres may change, the fuels required to satisfy the demand may be different and energy prices and costs may be impacted, too. In a longer-term perspective, products used for the energy transition (e.g. wind turbines, solar panel) could be affected due to the imposed adjustments on the primary materials required.

The analysis shows that these effects are rather limited at the EU level. Gross Inland Consumption in 2030 is virtually the same (-0.02 %) in a scenario with import CBAM compared to the MIX55 scenario[104]. Final energy consumption shows a similar result (+0.01 % in 2030). The fuel mix changes as some energy intensive goods are now produced within the Member States that would otherwise have been produced outside the EU. In final energy consumption, the most notable change is a slightly stronger shift from coal (-0.47 % in 2030) and towards distributed heat (+0.47 % in 2030) and hydrogen (after 2030). This shows that CBAM would have a positive impact in the uptake of fuels that facilitate a more decarbonised and flexible energy system, particularly for industry (also the sector strongest affected in energy terms by the measure). However, given the increase in overall consumption, the shares of the fuels in the energy mix stay the same. Because of the limited impacts on EU level, system costs are expected to remain largely the same (average 2021-2030), also in relation to GDP. Likewise, energy investments and energy related expenditures remain largely the same. On a Member State level, these effects naturally depend on the relative importance of particular industrial sectors in the overall energy consumption.

There is a limited impact on the products enabling the energy transition. The EU's production of batteries, electric vehicle transport equipment, equipment for wind power technology, equipment for photovoltaics and equipment for Carbon Capture and Sequestration (CCS) power technology decrease slightly compared to MIX55. The changes are in the range of -0.27 % to -0.79 % in 2030. However, CBAM is beneficial for the less mature clean technologies (hydrogen +0.33 %, and clean gas +0.31 % in 2030). Positive effects come mainly from increased domestic demand while negative effects originate mostly in a decrease in exports of these products.

[103] The results presented in this section are based on an energy system modelling exercise with FIMM, GEM-E3 and PRIMES models. While based on similar assumptions, the results are not identical due to differences in the models.
[104] The MIX55 scenario includes free allocation while the CBAM scenario assumes the removal of free allocation. The CBAM scenario modelled in this exercise is closest to option 3 of this impact assessment.

ANNEX 10: STATISTICAL ANNEX (TABLES AND REFERENCES TO THE MAIN TEXT)

1. Descriptive statistics on CBAM sectors

Overall CBAM sectors account for a relatively small share of the EU industry. Collectively they generate 0.790 % of total GVA (gross value added) and 2.610 % of total EU exports, while they are responsible for 2.324 % of EU imports.

Table 10-1: GVA, imports and exports of CBAM sectors in EU in 2020 (% of total)

	Iron and Steel	**Cement**	**Fertiliser**	**Aluminium**	**CBAM sectors**
GVA	0.45 %	0.12 %	0.11 %	0.11 %	0.79 %
Imports	1.23 %	0.06 %	0.34 %	0.68 %	2.32 %
Exports	1.56 %	0.08 %	0.43 %	0.54 %	2.61 %

Source: JRC-GEM-E3 model

As regards Member States, the picture is fairly homogenous with the EU average. Imports of CBAM sectors account for the largest shares of total imports from non-EU countries in Bulgaria and Italy followed by Slovenia and Romania, driven mostly by imports in iron and steel. While exports of CBAM sectors account for the largest shares in Romania, Lithuania and Estonia.

Table 10-2: GVA, imports and exports of CBAM sectors in EU Member States in 2020 (as % of total)

	Share of CBAM sectors in imports from non-EU countries	Share of CBAM sectors in exports to non-EU countries	Share of CBAM sectors' GVA in total GVA
AUT	3.2 %	3.6 %	1.4 %
BEL	3.5 %	4.1 %	0.7 %
BGR	12.1 %	3.8 %	1.4 %
CYP	1.0 %	1.8 %	0.7 %
CZE	2.4 %	2.4 %	0.6 %
DEU	2.3 %	2.4 %	0.8 %
DNK	2.3 %	1.4 %	0.9 %
ESP	2.7 %	3.8 %	0.6 %
EST	4.9 %	4.8 %	0.8 %
FIN	3.5 %	4.0 %	1.3 %
FRA	1.5 %	2.2 %	1.1 %
GRC	2.6 %	4.0 %	0.6 %
HUN	2.5 %	1.4 %	0.8 %
IRL	1.3 %	1.2 %	0.7 %
ITA	6.5 %	4.4 %	0.5 %
LTU	4.4 %	5.1 %	1.0 %
LUX	0.3 %	3.3 %	0.6 %
LVA	3.0 %	2.3 %	0.7 %
MLT	0.6 %	0.5 %	0.5 %
NLD	2.0 %	2.2 %	0.5 %
POL	3.9 %	3.0 %	0.9 %
PRT	4.3 %	3.8 %	0.8 %
SVK	4.4 %	3.8 %	0.8 %
SVN	5.3 %	2.8 %	1.2 %
SWE	2.5 %	3.5 %	1.5 %
ROU	6.3 %	6.3 %	1.2 %
CRO	6.7 %	4.6 %	0.9 %
EU27	2.3 %	2.6 %	0.8 %

Source: JRC-GEM-E3 model

When it comes to distribution of imports and exports by Member State, data for 2020 indicate that Italy, Germany, Belgium are leading importers of iron and steel, Germany, France, Italy and the Netherlands are the leading importers of cement, Germany, Belgium, France and Italy are the leading importers of fertilisers, and Germany, Italy, France and the Netherlands are the leading importers of aluminium.

On the export side Germany, France, Italy and Belgium are the biggest exporters of iron and steel, Germany, Spain, Italy, Denmark and Ireland are the biggest exporters of cement, Belgium, Germany and Ireland are the biggest exporters of fertilisers and Germany, Italy, and Poland are the biggest exporters of aluminium.

Table 10-3: Share of imports of Member States to EU27 total by CBAM sector (in 2020)

	Iron and steel	Cement	Fertilisers	Aluminium
AUT	1.3 %	2.1 %	1.0 %	5.9 %
BEL	12.9 %	2.5 %	11.9 %	5.0 %
BGR	4.3%	1.3 %	2.0 %	0.7 %
CYP	0.1%	0.2 %	0.1 %	0.0 %
CZE	1.6 %	1.2 %	1.4 %	1.5 %
DEU	13.8 %	10..7 %	15..8 %	32.9 %
DNK	2.5 %	1.1 %	1.1 %	1.1 %
ESP	9.3 %	2.7 %	6.0 %	3.5 %
EST	0.6 %	0.6 %	1.1 %	0.2 %
FIN	1.9 %	1.0 %	4.3 %	1.0 %
FRA	5.7 %	8.9 %	7.2 %	8.2 %
GRC	1.7 %	1.1 %	0.8 %	2.4 %
HUN	1.3 %	0.8 %	1.3 %	0.8 %
IRL	3.0 %	0.7 %	6.9 %	0.6 %
ITA	26.6 %	3.7 %	7.3 %	19..0 %
LTU	1.1 %	1.4 %	1.6 %	0.1 %
LUX	0.1 %	0.4 %	0.1 %	0.5 %
LVA	0.1 %	0.3 %	1.3 %	0.0 %
MLT	0.1 %	0.2 %	0.1 %	0.0 %
NLD	5.2 %	2.5 %	3.4 %	6.0 %
POL	5.3 %	2.7 %	4.6 %	4.0 %
PRT	2.7 %	0.2 %	0.9 %	0.2 %
SVK	1.6 %	0.4 %	1.6 %	0.5 %
SVN	0.5 %	0.4 %	0.1 %	1.6 %
SWE	3.3 %	3.4 %	2.0 %	1.5 %
ROU	3.3 %	1.4 %	1.2 %	0.3 %
CRO	0.3 %	0.9 %	1.6 %	0.5 %
EU27	100.0 %	100.0 %	100.0 %	100.0 %

Source: JRC-GEM-E3 model

Table 10-4: Share of exports of Member States to EU27 total by CBAM sector (in 2020)

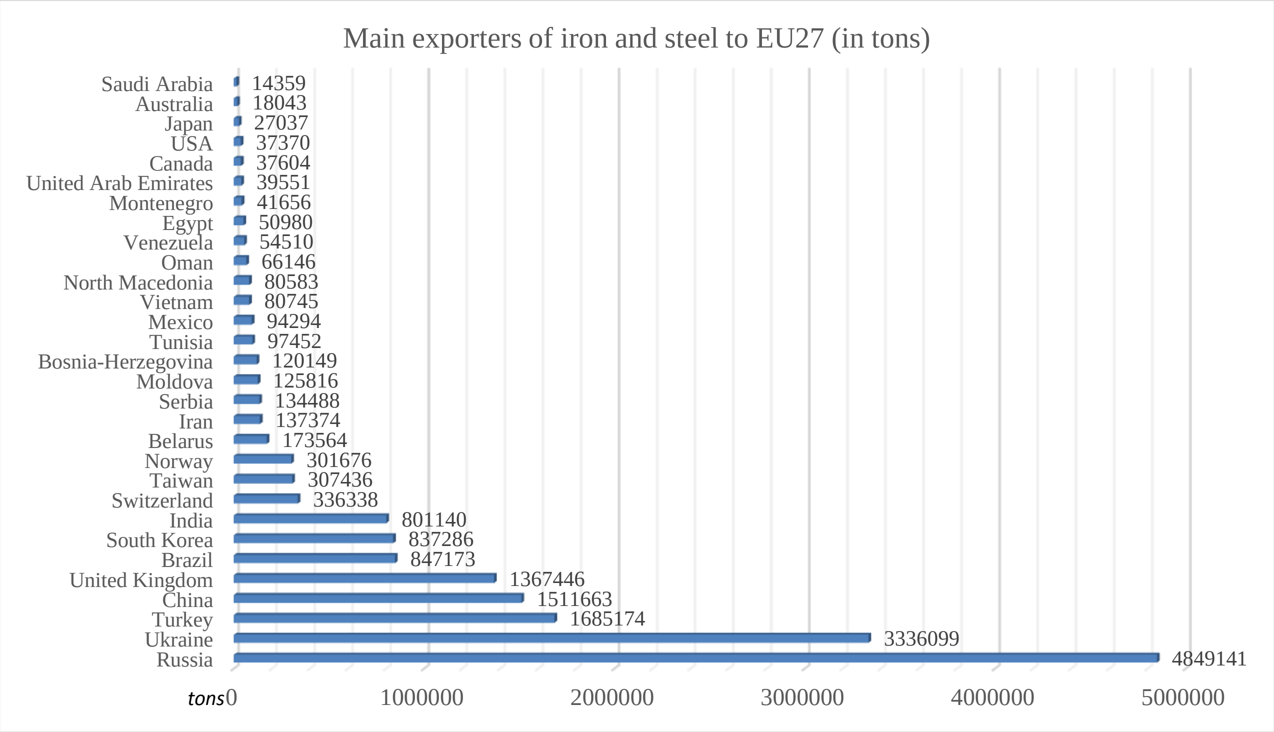
	Iron and steel	Cement	Fertilisers	Aluminium
AUT	3.6 %	1.0 %	0.8 %	4.0 %
BEL	6.0 %	1.3 %	27.2 %	1.3 %
BGR	0.8 %	0.6 %	0.5 %	0.4 %
CYP	0.0 %	2.3 %	0.0 %	0.3 %
CZE	1.5 %	1.4 %	0.4 %	0.7 %
DEU	17.5 %	8.8 %	12.2 %	38.2 %
DNK	1.1 %	5.8 %	0.2 %	1.7 %
ESP	8.2 %	9.9 %	3.0 %	6.5 %
EST	0.4 %	1.0 %	0.5 %	0.2 %
FIN	2.8 %	0.4 %	2.2 %	0.6 %
FRA	8.5 %	3.3 %	5.9 %	8.8 %
GRC	1.2 %	5.8 %	0.6 %	3.1 %
HUN	0.3 %	0.4 %	0.8 %	1.0 %
IRL	0.6 %	6.0 %	10.2 %	1.6 %
ITA	15.2 %	6.3 %	3.1 %	13.6 %
LTU	0.5 %	1.8 %	3.4 %	0.1 %
LUX	1.9 %	0.1 %	0.0 %	1.6 %
LVA	0.0 %	0.9 %	0.7 %	0.0 %
MLT	0.1 %	0.0 %	0.0 %	0.0 %
NLD	4.9 %	5.6 %	3.7 %	1.5 %
POL	1.2 %	3.1 %	4.5 %	5.1 %
PRT	1.8 %	5.6 %	0.3 %	0.6 %
SVK	1.2 %	0.4 %	0.0 %	0.3 %
SVN	0.4 %	0.2 %	0.0 %	0.5 %
SWE	6.1 %	1.2 %	1.2 %	1.4 %
ROU	2.7 %	0.2 %	1.3 %	0.9 %
CRO	0.1 %	6.4 %	0.9 %	0.2 %
EU27	100.0 %	100.0 %	100.0 %	100.0 %

Source: JRC-GEM-E3 model

2. Trade by partner

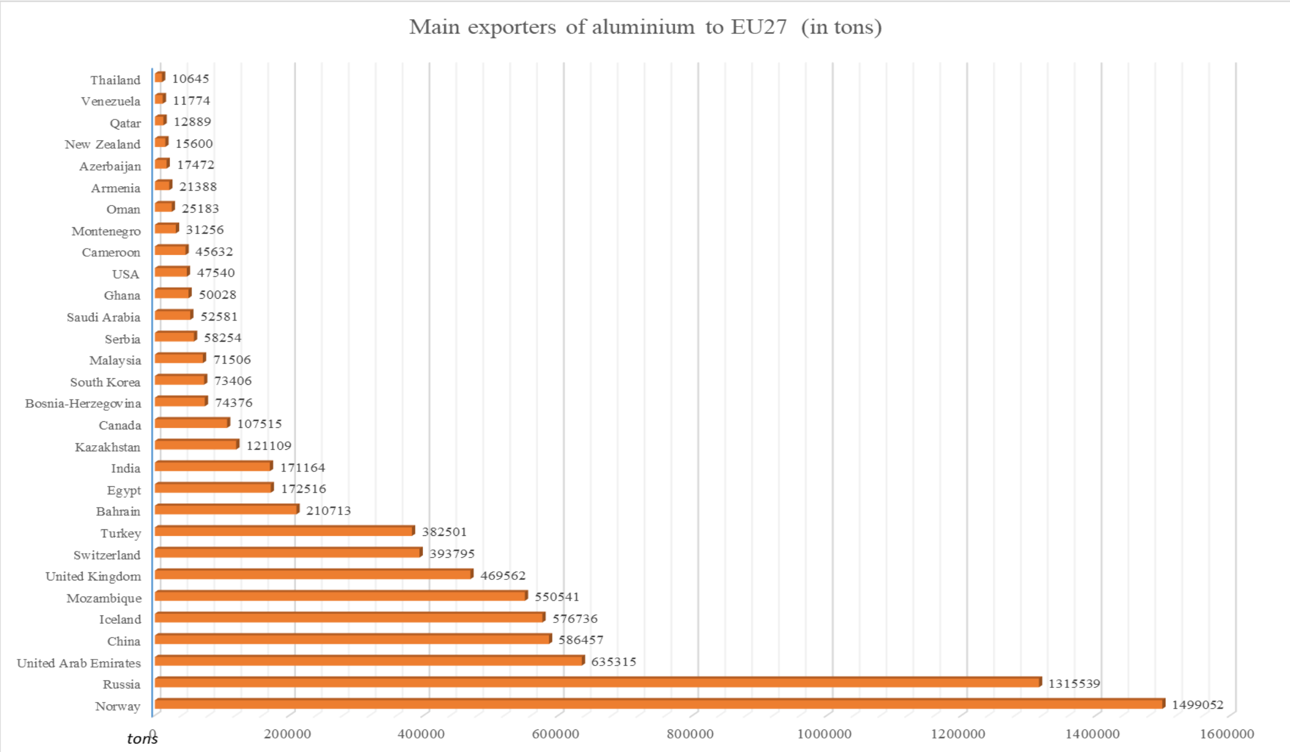
This section contains shows the main exporters of basic materials under the CBAM shortlist sectors (to be linked with section 6.4.3: Trade impacts)

Figure 10-1: Main exporters of Iron and steel to EU27 - 2019



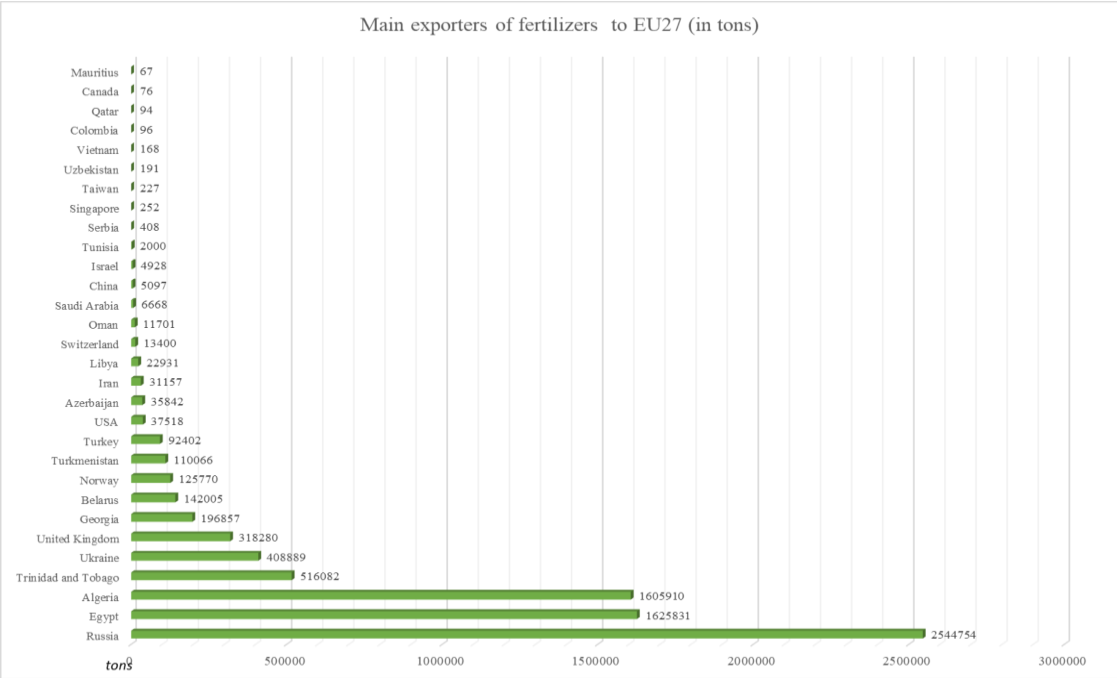
Source: Commission analysis based on data from Eurostat COMEXT

Figure 10-2: Main exporters of aluminium to EU27 - 2019



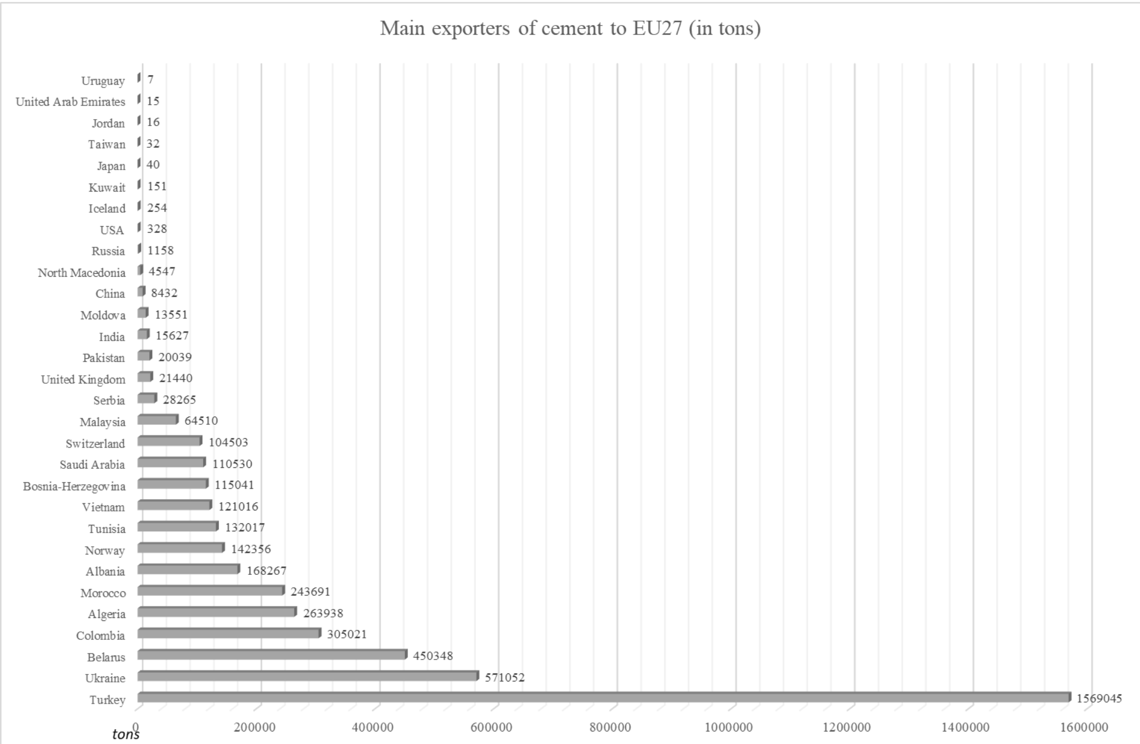
Source: Commission analysis based on data from Eurostat COMEXT

Figure 10-3: Main exporters of fertilisers to EU27 - 2019



Source: Commission analysis based on data from Eurostat COMEXT

Figure 10-4: Main exporters of cement to EU27 - 2019



Source: Commission analysis based on data from Eurostat COMEX

3. Distributional impacts

3.1 Methodological issues

Input microdata

This analysis uses Euromod's ITT extension and microdata from two household surveys:

- The European Union Statistics on Income and Living Conditions database, EU-SILC, which contains information on household income and other household- and individual-level characteristics
- and the EU Household Budget Surveys, from where information on household consumption expenditures at the 4 digits-COICOP categories of goods/services is extracted.

The Euromod's ITT extension uses as input a database obtained from matching these two surveys, in order to compute indirect tax liabilities (VAT and specific excise duties) for each household. These are calculated on top of the direct taxes, social contributions and cash benefits simulated by the core Euromod model.

Link between GEM-E3 and Euromod

First, the macroeconomic impacts of the CBAM scenarios are simulated in the JRC-GEM-E3 macro model. Then, in order to study the distributional impacts of the CBAM on households at the micro level, key variables from the macro simulation are used to feed the micro model. By linking the two models in this way, the distributional analysis at the micro level is able to account for the economy-wide impact of the CBAM under consideration, capturing the effects of the policy option not only through its direct impact on the tax burden, but also through its broader implications on consumer prices and household incomes.

It is important in this sense to mention the variables that are passed on from the macro model JRC-GEM-E3 to the micro model Euromod, as this can help interpret the microsimulation results. Firstly, on the expenditure side, Euromod is fed with the consumer price changes relative to the MIX-full auctioning scenario induced by the relevant CBAM option, as simulated by JRC-GEM-E3. This concerns 14 aggregate consumption categories based on COICOP groups, which are generated using consumption matrices embedded in the JRC-GEM-E3 model[105]. Since expenditures are imputed for each household at the commodity level, the mapping into these 14 categories only requires aggregation in Euromod. These price changes include both direct effects of carbon pricing and indirect price changes through inputs along the supply chain. Secondly, on the household income side, the relative changes to the baseline for both labour and capital income also feed the microsimulation. In this way, the economic environment of Euromod is approximated to the one foreseen by the JRC-GEM-E3 model.

[105] The 14 categories are: food beverages and tobacco, clothing and footwear, housing and water charges, fuels and power, household equipment and operation excluding heating and cooking appliances, heating and cooking appliances, medical care and health, purchase of vehicles, operation of personal transport equipment, transport services, communication, recreational services, miscellaneous goods and services and education.

All policy options simulated in the macro model assume the recycling of revenues from the CBAM based on a reduction of labour taxes to ensure budget neutrality within the JRC-GEM-E3 environment[106]. This is also reflected in the micro modelling through both the direct effect of the CBAM on (labour and capital) incomes as mentioned above, and the indirect effect from the recycling of CBAM revenues.

Drawing on this input from the JRC-GEM-E3 model, the distributional analysis is performed in Euromod by comparing for each considered CBAM option the adjusted disposable income (i.e. the disposable income net of indirect taxes) of households, by deciles, against the baseline. The baseline scenario in Euromod refers to the tax-benefit policy system in place as in 2019 in the Member State under consideration.

Furthermore, the impact of each CBAM scenario on household budgets, across the income distribution, is disentangled across two effects:

- The 'price effect', which captures the distributional effect of the CBAM scenario under analysis arising only from the predicted changes in consumer prices.
- The 'price and income effect', which adds to the price effect, the predicted changes in market income, which includes the recycling of CBAM revenue

3.2 Overall results

Microsimulations show that the CBAM options under analysis are regressive albeit the impacts are very small. The macro-simulated impact on labour/capital income and consumer prices are such that richer households would experience the largest increase (or lowest declines) of adjusted disposable income (disposable income after indirect taxes), while the poorest are often the most adversely affected. The distributive impact depends on the policy option and largely differs across countries.

In general, the three CBAM options considered show the following impacts on household incomes across the income distribution, for each of the two drivers (price and income, in both cases including the compensation mechanism):

i) ***A negative and regressive 'price effect'.*** All the scenarios considered drive a price rise in a number of consumption categories, mainly in transport, fuels and power, as well as heating. Although prices of other categories are expected to decrease (mostly in services related with housing and water, communication, recreational services and education), overall, household adjusted disposable incomes are expected to fall across the whole income distribution through the price effect. In most countries, CBAM is regressive, as this affects more heavily households at the bottom of the income distribution, for their income share of consumption is notably larger.

ii) ***A positive and regressive 'income effect'.*** All the options generally lead to an increase of labour and capital income, which benefits more the households in the second half of the income distribution.[107] Differently from the 'price

[106] As emphasized earlier this approach ensures budget neutrality for modelling purposes, rather than defining how additional revenues from CBAM as an own resource could be used.

[107] It is worth noting that surveys data, such as EU-SILC, measure labour income much more accurately than capital income. Therefore, changes in labour-earning are the main driver of the overall income effects in our analysis.

effect', the 'income effect' produces a positive impact on household adjusted disposable incomes across the board. However, it is regressive: poorer households benefit relatively less, since they rely more on replacement income (such as pensions or unemployment benefits) or non-contributory cash benefits (such as social assistance). The revenue recycling possibly reinforces this regressivity, since many households at the bottom do not pay labour taxes, so they cannot benefit from this compensatory measure. Nevertheless, the magnitude of the overall distributional impacts remains very small.

The overall impact of all the CBAM options under consideration (cum the compensation mechanism) is however very small. That is because the expected changes in prices and incomes coming from the JRC-GEM-E3 model are very small and so is their impact on household adjusted disposable income. For example, for the first decile the impact on disposable income ranges from -0.11 % (Lithuania, option 6) to 0.07 % (Lithuania, options 1 and 2). Beyond the first decile, the largest negative impact across all countries and scenarios is observed in Greece and Romania, in their second decile, in option 6 (of about -0.06 %), while the largest positive impact is observed in Belgium (options 1 and 2, 9th decile: 0.24 %).

Options 1 and 2 have the lowest estimated impact on poorer household incomes, while options 4 and 6 display a larger impact. In these latter scenarios, the worst affected households are those in the first decile who experience a decrease in adjusted disposable income between -0.15-2.1 % (option 4, in Lithuania, Slovakia and Romania) and of 0.1 % (option 6, in Lithuania, Romania, Germany and Greece). On the other hand, in option 1/2 the largest fall in adjusted disposable income for households in the first decile is about a fifth of it (i.e. about -0.015 % in Denmark, Finland, France and Slovenia).

Within each CBAM scenario, results substantially vary across countries. This is due to the different impact that the CBAM produces on prices of each good category and on incomes in each country. Country disparities are also explained by the different consumption patterns across the income distribution and the income structure of households.

3.3 Distributional impacts of each policy option

Impacts of options 1 and 2

Figure 10-5 presents the change in equivalized household adjusted disposable income, relative to disposable income, resulting from CBAM options 1 and 2.

Each figure groups six countries, which are classified according to the magnitude of the impact of the CBAM option over the first decile of the income distribution (household disposable income in the baseline). Figure 10-6(a) shows the group of countries with mildest impact on the first decile; 10-6(c) the countries with the strongest impact and 10-5(b) those in between.

Results for the 18 Member States suggest:

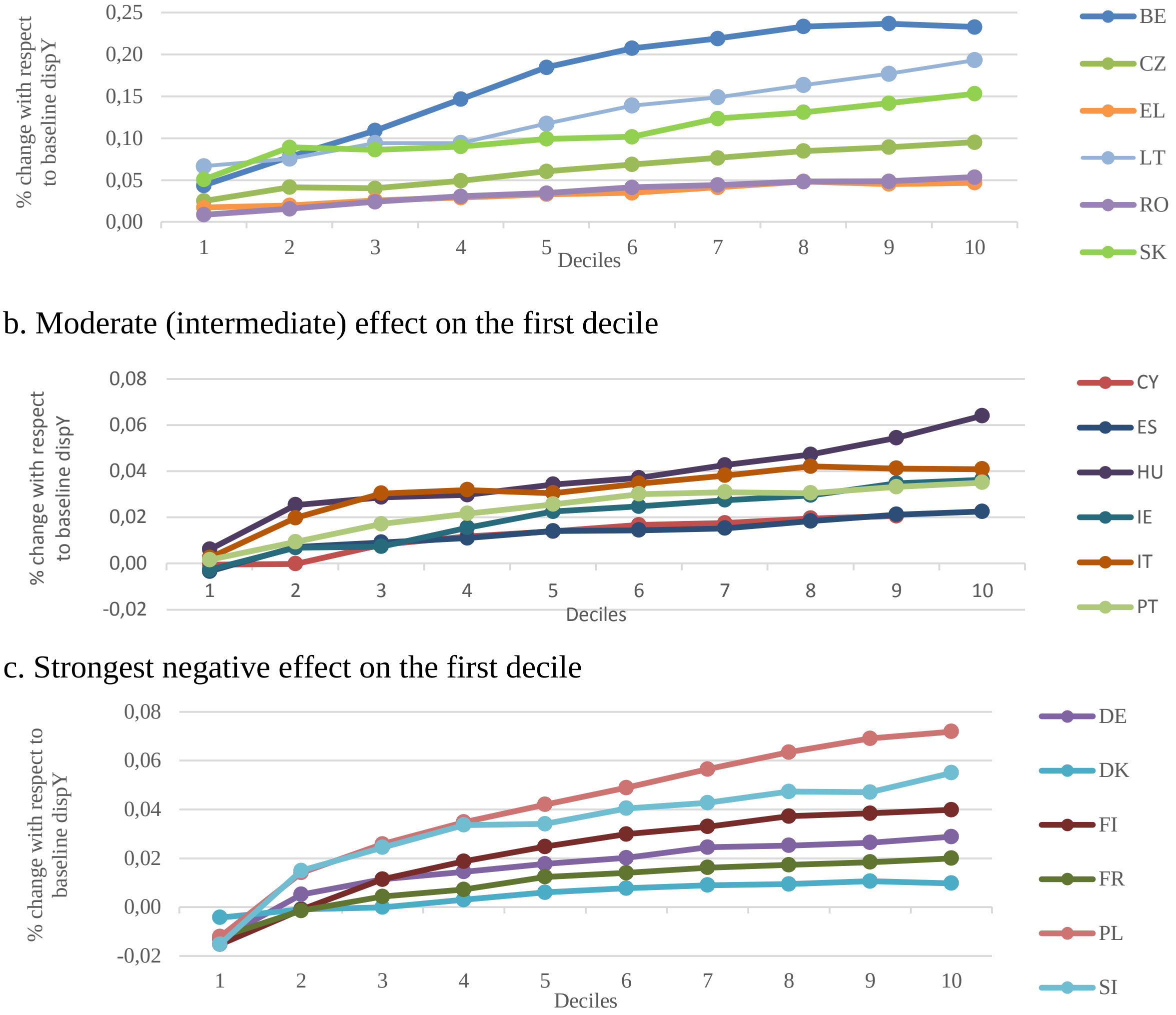
- In general, the impact of this CBAM option (combined with the compensation mechanism) over household incomes is positive for all households from the second decile onwards. That is because this policy option implies a larger effect in earnings than in prices. The overall impact however is of a very small magnitude, ranging from -0.015 % (Slovenia and Finland, 1st decile) to 0.24 % (Belgium, 9th decile).
- In more detail, the impact over the first decile ranges from 0.05–0.07 % for the cases of Slovakia and Lithuania, to -0.10 % for France and Slovenia. At the other extreme, Belgium is the country where the richest are relatively more benefited, with adjusted disposable income increasing by more than 0.23 % in the ninth and in the tenth decile.

Figure 10-5. % change in adjusted disposable income resulting from Options 1 and 2

a. Mildest effect on the first decile

b. Moderate (intermediate) effect on the first decile

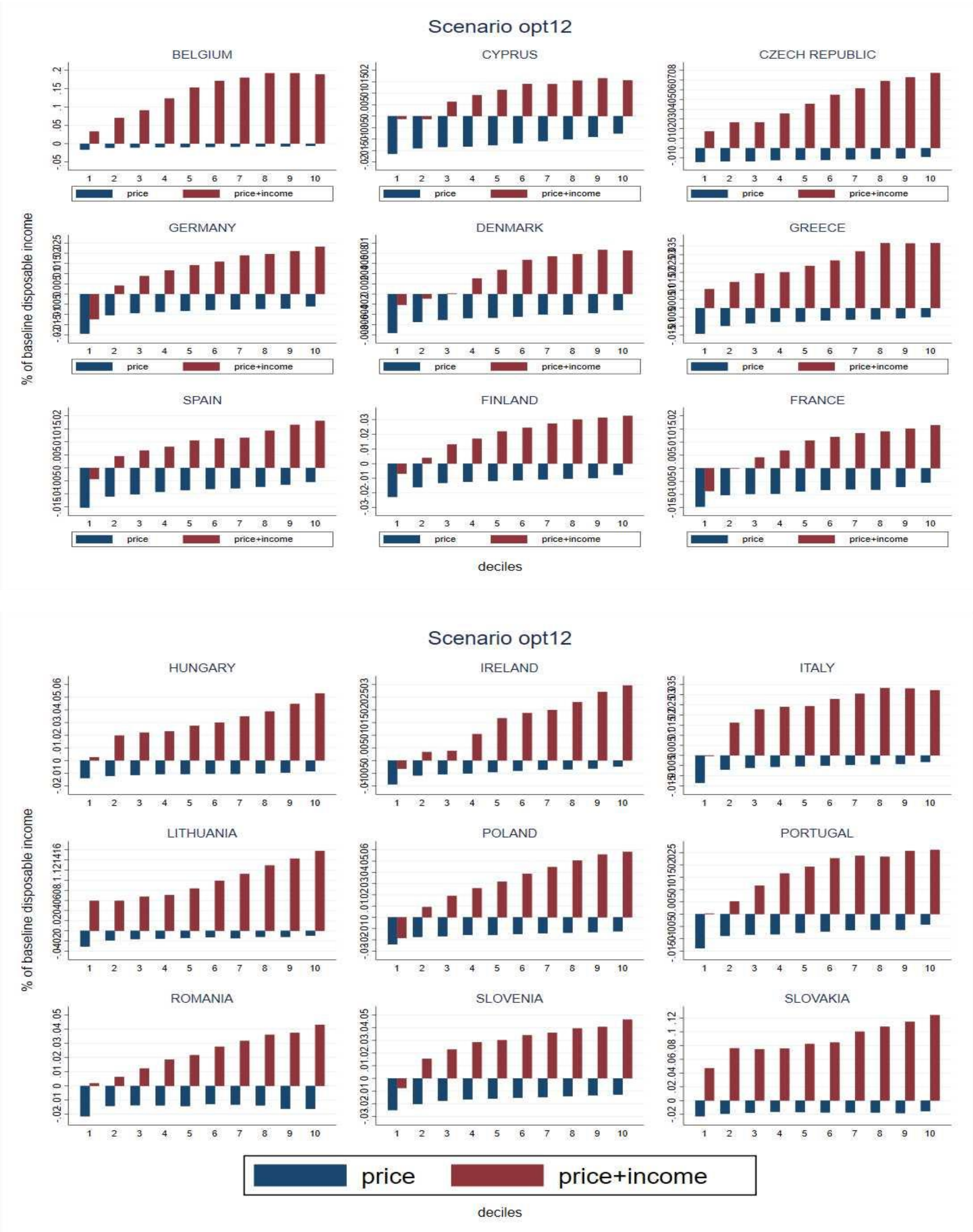
c. Strongest negative effect on the first decile



Note: Plots show the total effect of the CBAM (including the compensatory measure) expressed as the % change in adjusted disposable income in relation to household disposable income in the baseline. Deciles of equivalent household disposable income in the baseline. Adjusted disposable income is the residual of household disposable income after the subtraction of indirect taxes (VAT and excise duties). The scaling of y-axis differs across the three groupings. Equivalence scales used are the standard 'OECD-modified' ones.

Source: European Commission's Joint Research Centre, based on the Euromod model.

Figure 10-6: % change in adjusted disposable income resulting from CBAM option 1/2: price and income effects country by country



Note: Plots show the total effect of the CBAM (including the compensatory measure) expressed as the % change in adjusted disposable income in relation to household disposable income in the baseline. Deciles of equivalent household disposable income in the baseline. Adjusted disposable income is the residual of household disposable income after the subtraction of indirect taxes (VAT and excise duties). Equivalence scales used are the standard ‘OECD-modified’ ones.

Source: European Commission’s Joint Research Centre, based on the Euromod model.

Impacts of option 4

Figures 10-7 present the change in equivalised household adjusted disposable income, relative to disposable income, resulting from CBAM option 4.

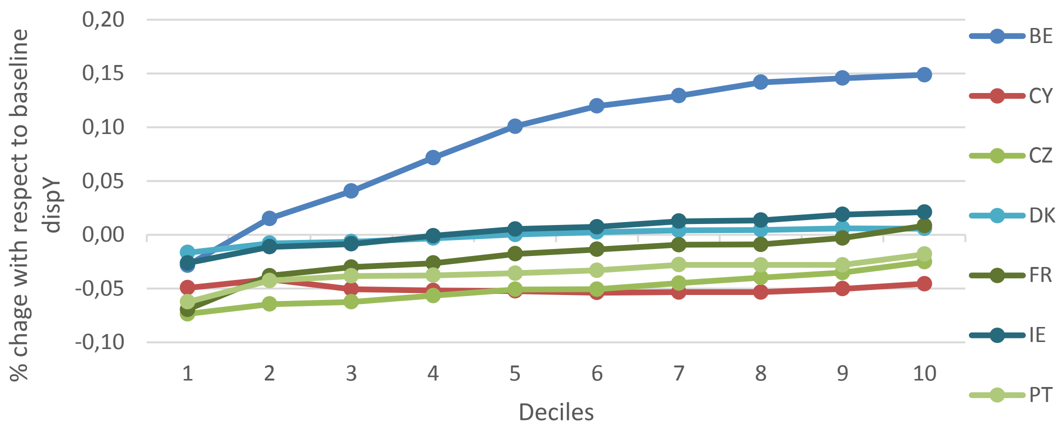
Each figure groups a number of countries, classifying them according to the magnitude of the impact of the CBAM over the first decile of the income distribution. Figure 10-8(a) shows the group of countries with mildest impact on the first decile, 10-8(c) the countries with the strongest impact and 10-8(b) those in between.

Results for the 18 Member States suggest:

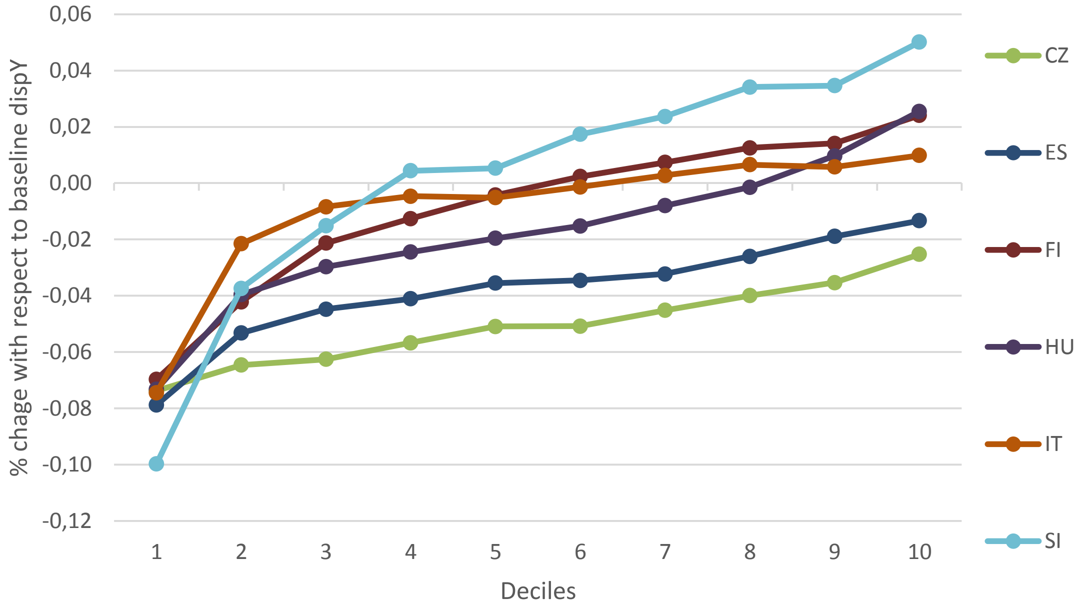
- In most countries, the impact of this CBAM option (combined with the compensatory measure) is negative for households in the first half of the distribution, whereas it is positive for households of the second half. Romania seems to be the only country where the richest are more severely affected than the poorest (although they all lose across the board), while Denmark and Cyprus show the more neutral/flat patterns (households are all similarly affected across the income distribution). The impact on household incomes is small in magnitude with the worst affected in Lithuania, suffering a loss worth about -0.21 % of their disposable income. At the other extreme, the richest households in Belgium experience a gain of about the same amount (i.e. around 0.14 %).

Figure 10-7: % change in adjusted disposable income resulting from CBAM option 4

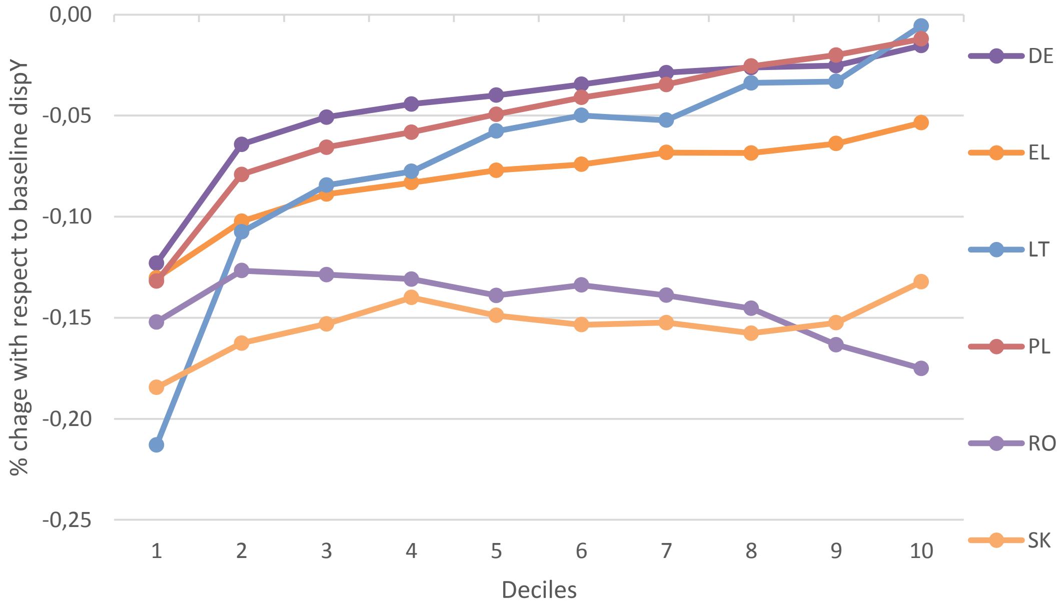
a. Mildest effect on the first decile



b. Moderate (intermediate) effect on the first decile



c. Strongest negative effect on the first decile



Note: Plots show the total effect of the CBAM (including the compensatory measure) expressed as the % change in adjusted disposable income in relation to household disposable income in the baseline. Deciles of equivalent household disposable income in the baseline. Adjusted disposable income is the residual of household disposable income after the subtraction of indirect taxes (VAT and excise duties). The scaling of y-axis differs across the three groupings. Equivalence scales used are the standard 'OECD-modified' ones.

Source: European Commission's Joint Research Centre, based on the Euromod model.

Figure 10-8: % change in adjusted disposable income resulting from CBAM option 4: price and income effects country by country

Note: Plots show the total effect of the CBAM (including the compensatory measure) expressed as the % change in adjusted disposable income in relation to household disposable income in the baseline. Deciles of equivalent household disposable income in the baseline. Adjusted disposable income is the residual of household disposable income after the subtraction of indirect taxes (VAT and excise duties). Equivalence scales used are the standard 'OECD-modified' ones.

Source: European Commission's Joint Research Centre, based on the Euromod model.

Impacts of option 6

Figure 10-9 presents the change in equivalised household adjusted disposable income, relative to disposable income, resulting from option 6.

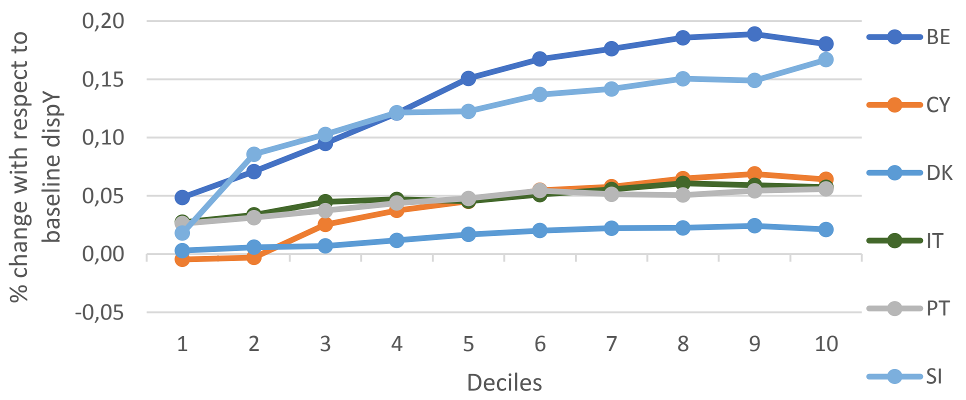
Each figure groups a number of countries, classifying them according to the magnitude of the impact of the CBAM over the first decile of the income distribution. Figure 10-9(a) shows the group of countries with mildest impact on the first decile, 10-9(c) the countries with the strongest impact and 10-9(b) those in between.

Results for the 18 Member States suggest:

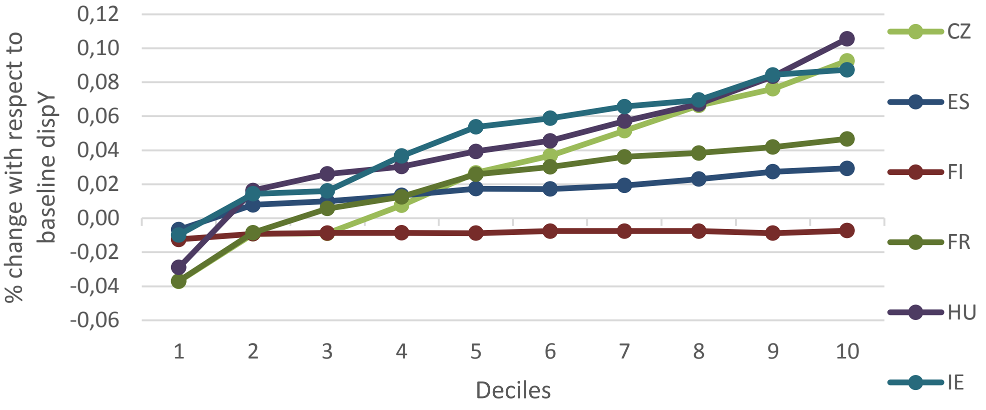
- In most countries, the impact of this CBAM option (combined with the compensatory measure) is positive for all households situated on the third decile of the distribution onwards. It is, instead, often negative for households sitting in the first two deciles (with the main exception of Belgium, Portugal, Italy, Slovenia and Denmark).
- The impact on household incomes is small in magnitude, with the worst affected being Lithuania, Romania, Germany and Greece first decile households who are suffering a loss worth about -0.10 % of their disposable income. At the other extreme, the richest households in Belgium and Cyprus experience a gain in excess of 0.15 %.

Figure 10-9: % change in adjusted disposable income resulting from Option 6

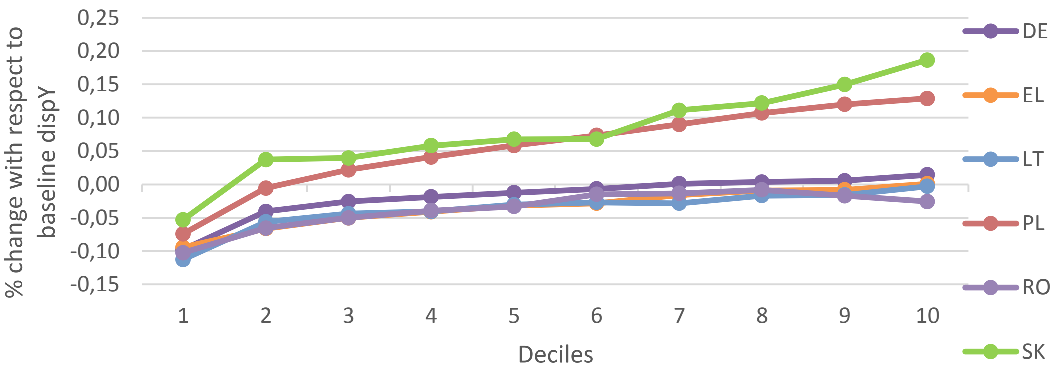
a. Mildest effect on the first decile



b. Moderate (intermediate) effect on the first decile



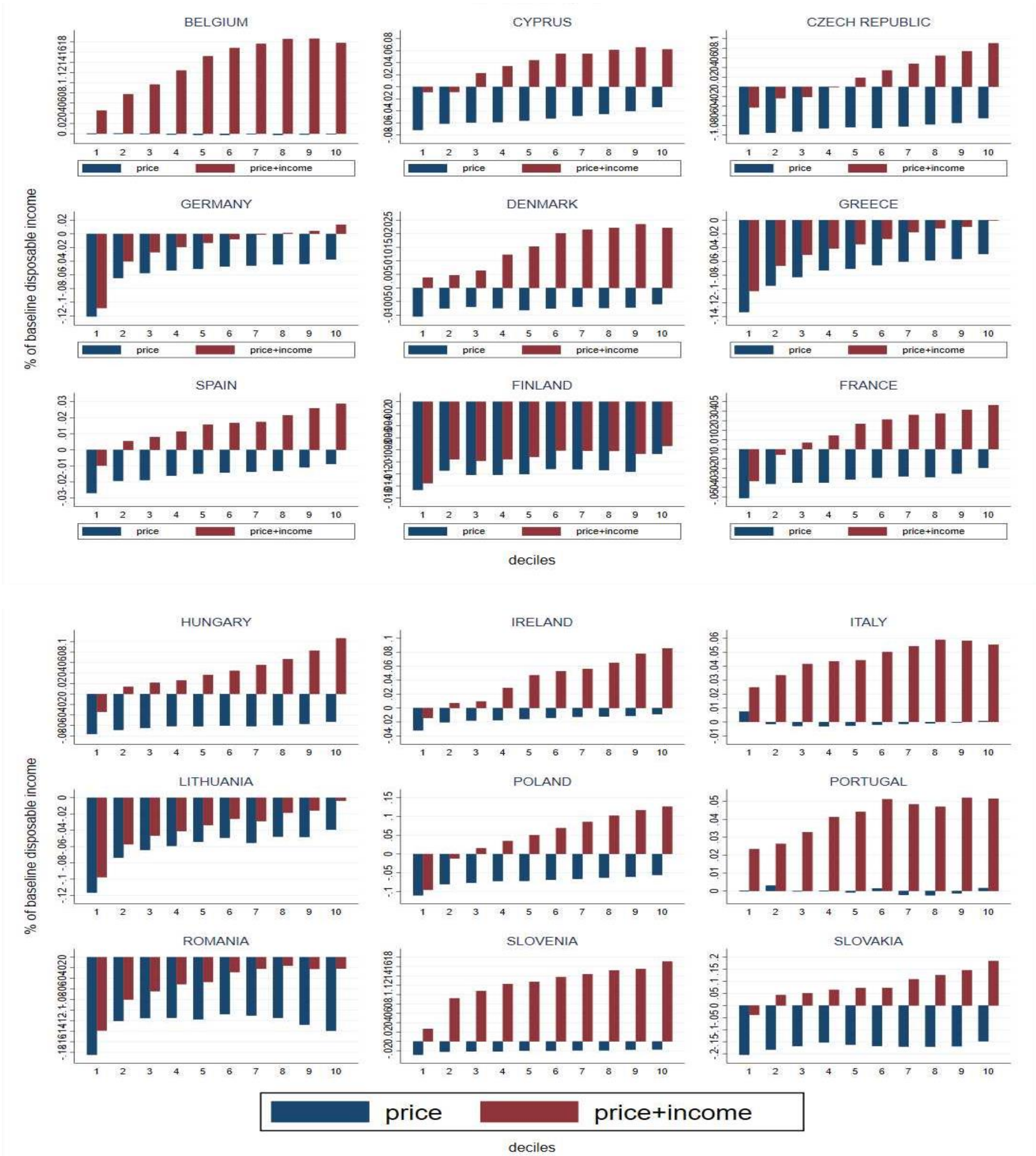
c. Strongest negative effect on the first decile



Note: Plots show the total effect of the CBAM (including the compensatory measure) expressed as the % change in adjusted disposable income in relation to household disposable income in the baseline. Deciles of equivalent household disposable income in the baseline. Adjusted disposable income is the residual of household disposable income after the subtraction of indirect taxes (VAT and excise duties). The scaling of y-axis differs across the three groupings. Equivalence scales used are the standard 'OECD-modified' ones.

Source: European Commission's Joint Research Centre, based on the Euromod model.

Figure 10-10: % change in adjusted disposable income resulting from CBAM option 6: price and income effects country by country



Note: Plots show the total effect of the CBAM (including the compensatory measure) expressed as the % change in adjusted disposable income in relation to household disposable income in the baseline. Deciles of equivalent household disposable income in the baseline. Adjusted disposable income is the residual of household disposable income after the subtraction of indirect taxes (VAT and excise duties). Equivalence scales used are the standard ‘OECD-modified’ ones.

Source: European Commission’s Joint Research Centre, based on the Euromod model.

4. Results for option 4 including impacts of resource shuffling

Resource shuffling may occur in all options where imports may be subject to a CBAM based on actual emissions, in practice options 1 to 5.

To assess the potential impacts of resource shuffling, a variant of option 4 was also modelled introducing the assumption that exporters to the EU would be able to claim lower emission intensities. Based on available estimates in the literature –as discussed in the main report- these were assumed to be 50 % lower for cement and iron and steel, and 80 % lower for aluminium. No resource shuffling was assumed for fertilisers as no reliable estimates could be sourced from available studies. The results as compared to the main findings are presented in Table 10-5 below.

Table 10-5: Impacts on carbon leakage, emissions, imports and revenues with and without resource shuffling (in 2030)

	MIX	MIX full auctioning	Option 4	Option 4 with resource shuffling
Carbon Leakage (%)				
Iron and Steel	8	37	-24	0
Cement and Lime	4	31	7	13
Aluminium	24	36	-89	8
Change in Emissions in the EU (% change from baseline)				
Iron and Steel	-14.5	-17.4	-14.6	-15.4
Cement and Lime	-11.9	-16.0	-14.0	-14.2
Aluminium	-10.0	-16.9	-12.6	-13.9
Change in Emissions in the non-EU (% change from baseline)				
Iron and Steel	0.14	0.72	-0.44	-0.02
Cement and Lime	0.03	0.27	0.05	0.10
Aluminium	0.13	0.25	-0.03	0.17
Imports of CBAM sectors (% change from baseline)				
Iron and Steel	1.45	11.01	-11.98	-2.38
Cement and Lime	3.39	45.88	-15.12	6.97
Aluminium	2.07	3.64	-4.41	1.75
Revenue[108] (bn Euro)				
Revenue from auctioning			7.0	6.9
Revenue collected at the border			2.1	1.3
Total revenue			9.1	8.2

Source: JRC-GEM-E3

[108] Includes fertilisers

5. Implied CBAM tariff equivalent

Tariff equivalents were estimated on the basis of model results. They are based on the ratio of revenue generated from the carbon price applied to implied emissions of imports in the CBAM sectors over the corresponding import flow (CIF).

Table 10-6: Implied tariff equivalent by different CBAM sectors - 2030

	Iron and Steel	Cement and Lime	Fertiliser	Aluminium	CBAM sectors
Options 1 and 2	2.8%	9.9%	3.0%	0.6%	2.3%
Option 3	5.1%	13.5%	8.3%	1.1%	4.4%
Option 4	4.2%	9.8%	7.5%	0.9%	3.6%
Option 5	5.1%	13.5%	8.3%	1.1%	4.4%

Source: JRC-GEM-E3

Table 10-7: Implied tariff equivalent by different downstream sectors - 2030

	Other non-ferrous metals	Chemical Products	Electric Goods	Transport Equipment	Other Equipment	Consumer Goods
Option 5	0.03%	0.08%	0.02%	0.03%	0.14%	0.02%

Source: JRC-GEM-E3

ANNEX 11: EVIDENCE OF CARBON LEAKAGE

The existence of carbon leakage is assessed in different ways. A number of studies are 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 of carbon allowances. Böhringer et al. present the estimation of economy wide carbon leakage models[109] 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 find a typical range of carbon leakage estimates between 5 % and 25 % with a mean at 14 % without any adjusting policy[110]. 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[111]. In other studies, partial equilibrium models are applied to specific industries. These studies tend to focus on emission-intensive and trade-exposed sectors and find higher leakage rates for these sectors in particular[112].

Ex-post studies quantify the existence of carbon leakage based on trade flows and embodied GHG 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. did not find evidence for effects on trade in emission-intensive and trade-exposed sectors caused by the EU ETS[113]. Similarly, Naegele and Zaklan conclude that carbon leakage has not occurred, based on input-output data and administrative data of the EU ETS[114]. In a review study, Dechezlepretre and Sato 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[115]. If other costs like tariffs and transportation outweigh the carbon price, relocation of production is not attractive[116].

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

[109] Böhringer, C., Carbone, J. C., & Rutherford, T. F., 'Embodied Carbon Tariffs', *The Scandinavian Journal of Economics*, 120(1), 2018, pp.183–210. https://doi.org/10.1111/sjoe.12211

[110] Branger, F., & Quirion, P., 'Would border carbon adjustments prevent carbon leakage and heavy industry competitiveness losses? Insights from a meta-analysis of recent economic studies', *Ecological Economics*, Vol 99, 2014, pp.29–39. https://doi.org/10.1016/j.ecolecon.2013.12.010

[111] Böhringer, C., Carbone, J. C., & Rutherford, T. F., 'Embodied Carbon Tariffs', *The Scandinavian Journal of Economics*, 120(1), 2018, pp.183–210. https://doi.org/10.1111/sjoe.12211

[112] Demailly, D., & Quirion, P., 'European Emission Trading Scheme and competitiveness: A case study on the iron and steel industry', *Energy Economics*, 30(4), 2008, pp. 2009–2027. https://doi.org/10.1016/j.eneco.2007.01.020

[113] Branger F., Quirion, P., & Chevallier, J., 'Carbon Leakage and Competitiveness of Cement and Steel Industries Under the EU ETS: Much Ado About Nothing', *The Energy Journal*, 37(3), 2016, pp. 109–135. https://doi.org/10.5547/01956574.37.3.fbra

[114] Naegele, H., & Zaklan, A., 'Does the EU ETS cause carbon leakage in European manufacturing?' *Journal of Environmental Economics and Management*, 93, 2019, pp. 125–147. https://doi.org/10.1016/j.jeem.2018.11.004

[115] Dechezleprêtre, A., & and Sato, M., 'The Impacts of Environmental Regulations on Competitiveness', *Review of Environmental and Economics and Policy*, vol. 11(2), 2017, pp. 183-206.

[116] Naegele, H., & Zaklan, A., 'Does the EU ETS cause carbon leakage in European manufacturing?' *Journal of Environmental Economics and Management*, 93, 2019, pp. 125–147. https://doi.org/10.1016/j.jeem.2018.11.004

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[117].

[117] Neuhoff, K., & Ritz, R., 'Carbon cost pass-through in industrial sectors', 2019. https://doi.org/10.17863/CAM.46544