

DISCUSSION NOTE

Review of calculation methods for embedded emissions for the purpose of the CBAM (Version for discussion with stakeholders)

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1 INTRODUCTION

This note serves to summarise the findings under Task 1 “Review of calculation methods applicable in the EU ETS for the CBAM goods” of the project “Study on analytical methods for the calculation of embedded emissions in goods under the CBAM scope” for the European Commission (DG TAXUD).

The CBAM (Carbon Border Adjustment Mechanism) is intended as an environmental policy instrument, in particular for mitigating the risk of carbon leakage in industries covered by the EU ETS (EU Emission Trading System). It should thereby support the mitigation of greenhouse gas (GHG) emissions. The principle of the CBAM is to subject goods imported into the EU to a carbon price equivalent to that applied within the EU. Producers inside the EU are affected by the CO₂ price in place due to the EU ETS. Producers outside the EU who export products into the EU will face CO₂ costs from the CBAM that are closely reflecting the situation of the EU ETS. This can only be achieved if not only the CO₂ price is similar to the one in the EU ETS¹, but it also requires that the rules for determining the GHG emissions of the relevant industries are as similar to the EU ETS rules as possible. However, since in the case of CBAM non-EU operators of industrial installations have to perform emissions monitoring, it should be explored to what extent already existing monitoring rules (such as contained in ISO standards) can be adapted to the requirements of the CBAM.

The paper starts by discussing the concept and definition of “Embedded emissions” for the use in the CBAM Regulation in chapter 2. For this purpose, it is analysed if the concept of a *Carbon Footprint of Products (CFP)* as departing point would be useful, and which parts of a CFP would be covered by the EU ETS. As it will be shown, for establishing comparable carbon costs for both producers under the EU ETS and producers outside the EU, but covered by the CBAM, those elements of the CFP covered by the EU ETS (i.e. a very specific form of a *partial CFP*²) should be considered “embedded emissions” of the products covered by the CBAM.

Chapter 3 thereafter discusses the principles that will be needed to set up a system for MRV (Monitoring, Reporting and Verification) for embedded emissions. In section 3.3, general principles for MRV in CBAM context are developed. These are deducted mainly from the EU ETS, but as it will be shown in section 4, they are not so different from other GHG monitoring systems. Then, in section 3.4 the monitoring methods required are presented, again building on the EU ETS legal framework, followed by an outline of step-by-step calculation rules for the CBAM in section 3.5. Adding to the principles of MRV, section 3.6 deals with the requirements for system boundaries. For completing this chapter, section 3.7 discusses lessons that can be learned from the EU ETS compliance cycle, and

¹ This will be achieved by linking the price of the CBAM certificates closely to the actual market price of EU ETS allowances.

² Taking into account concepts of ISO 14067

closes with considerations about a governance system which could be built on the experience from the RED II (Renewable Energy Directive).

Next, chapter 4 provides an overview of the already existing legal framework for MRV in the EU ETS and what can be learned from it for the CBAM. The chapter also explores to what extent international standards or MRV rules from other carbon pricing systems can supplement or partly replace rules on EU ETS basis, as it may be helpful for the CBAM if a carbon pricing system or a mandatory MRV requirement is in place in a country where goods for the export to the EU are produced.

Chapter 5 presents then an overview of the production processes and value chains for the sectors and goods to be included in the scope of the CBAM. For these, detailed rules on system boundaries will have to be developed during the following project task.

Purpose of this document: This note was developed for discussion of the general approach to determining embedded emissions with stakeholders. It may furthermore be considered a useful input to any impact assessments to improve the CBAM Regulation at a later point in time.

Note on the temporal context of this note:

The overwhelming part of this note was drafted before the provisional political agreement by the European Parliament and the Council was reached (on 13 December 2022). It is therefore referring to the Commission proposal³ of 14 July 2021 as the main basis for the discussion. However, where necessary or more useful, reference is made to the provisional text⁴ of the CBAM Regulation following the provisional political agreement. The latter must still be confirmed by ambassadors of the EU Member States, and by the European Parliament, and adopted by both institutions (and published in the Official Journal of the EU) before it is final.

³ Proposal for a Regulation of the European Parliament and of the Council establishing a carbon border adjustment mechanism, COM/2021/564 final; <https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52021PC0564>

⁴ <https://data.consilium.europa.eu/doc/document/ST-16060-2022-INIT/en/pdf>

2 EMBEDDED EMISSIONS AND CARBON FOOTPRINT

As a starting point for deciding on the concept of “embedded emissions”, it was already found in DG TAXUD’s previous study⁵ that it should be built on the principles and requirements for a carbon footprint of products (CFP). As it was also stated in section 5.2.2 of that study, a very specific type of “partial CFP” would have to be defined in order to make the resulting “CBAM obligation” (embedded emissions expressed as number of CBAM certificates to be surrendered) comparable to the carbon costs incurred when the same production processes would take place in the EU, i.e. to the “EU ETS obligation” (expressed as number of EU ETS allowances (EUAs) to be surrendered along the same value chain as the product under consideration).

In order to make this line of argumentation better accessible to readers coming from the LCA⁶ and CFP perspective (using in particular ISO 14067:2018⁷ and the European PEF⁸ standard), in the following sections we will briefly discuss the reasoning which lead to the existing definition of embedded emissions as it is given in the Commission proposal for the CBAM Regulation⁹ (in this document referred to simply as “the CBAM Regulation” or “the Commission’s proposal”).

2.1 Concepts of carbon footprints of products

A carbon footprint of a product is usually understood as an amount of GHG-emissions (expressed as kg or t CO₂e) per *declared unit*, e.g. a tonne of good, or per a specific unit of service (a *functional unit*¹⁰). It is understood to be based on

⁵ Ramboll, DIW, Umweltbundesamt at al. 2022, Study on the possibility to set up a carbon border adjustment mechanism on selected sectors (Study for DG TAXUD), <https://op.europa.eu/en/publication-detail/-/publication/c274955e-b16b-11ec-83e1-01aa75ed71a1/language-en/format-PDF/source-search>

⁶ Life Cycle Assessment

⁷ ISO 14 067:2018 – Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification

⁸ PEF is the Product Environmental Footprint (which has a much wider perspective than a CFP. However, a CFP is a subset of a PEF. For details see “Recommendation on the use of Environmental Foot-print methods” https://environment.ec.europa.eu/publications/recommendation-use-environmental-footprint-methods_en

⁹ Proposal for a Regulation of the European Parliament and of the Council establishing a carbon border adjustment mechanism, COM/2021/564 final; <https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52021PC0564>
Impact assessment: SWD/2021/643 final <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021SC0643&qid=1657361755832>

¹⁰ Functional units are used where different options for a service are to be compared, e.g. comparison of a number of uses of recyclable goods against the same number of single-use goods.

a life cycle perspective covering all significant emissions from upstream and downstream processes (called life cycle stages), such as:

- mining of raw materials;
- manufacture of materials and intermediate products needed for the manufacture of the product;
- transport of raw materials and interim products to the site of the production process;
- the production process – including all relevant upstream processes (e.g. provision of the amount of energy required);
- transport of the product to the consumer;
- the use stage;
- end-of-life stage of the product (collection, refurbishment, re-use, recycling, disposal).

The international standard ISO 14067 (“Greenhouse gases – Carbon footprint of products – Requirements and guide-lines for quantification”) is commonly accepted as the indispensable rulebook to be followed. It builds on ISO 14040 (“Environmental management – Life cycle assessment – Principles and framework”) and ISO 14044 (“Environmental management – Life cycle assessment – Requirements and guidelines”). However, as standards are not freely available, and not always easy to translate into the concrete rules to be followed by users, a more popular source of information is the “GHG Protocol”¹¹. In the EU, the PEF⁸ is considered the most important and comprehensive standard (with overall strong compatibility to the ISO standards mentioned).

By and large, requirements are comparable in these systems. However, it would be misleading to state that application of these standards alone led to harmonised and unambiguous ways to calculate a carbon footprint. The standards and guidance documents present a framework of requirements, but leave the user with significant flexibility and still allow – or even require – a plethora of methodological choices (e.g. decisions on specific allocation procedures along the value chain or generic sources for the integration of background data) for solving specific issues before the carbon footprint result can be expressed. Therefore all systems require extensive reporting to make the underlying assumptions and data sources transparent for meaningful interpretation. Against these requirements it has to be kept in mind that for the CBAM – just like for the

¹¹ Developed by World Resources Institute (www.wri.org) and World Business Council for Sustainable Development (www.wbcsd.org).

EU ETS – the aim is to come up with one exact figure¹² for the number of certificates to be surrendered. Hence, rules are required to ensure that the producer of goods under the CBAM can come up with exactly such figure.

For making data of different life cycle assessment quantifications comparable (comparable between products of different producers, but also comparable across systems, like in this case CBAM and EU ETS), it is required to have common definitions of system boundaries (product definition and production process boundaries). The setting of system boundaries includes a definition of which parts of the installation producing the goods have to be included in the emission monitoring, and which raw materials, fuels, and energy flows to or from the production process. It is furthermore important to clarify which upstream processes (production of precursor materials) and further processing steps (e.g. rolling or casting, cleaning and coating of steel products) are included within the system boundaries. For the CBAM, such product definitions need to be set such that they are aligned with the CN codes which define the CBAM's scope. Further clarification is required for several practical issues such as the treatment of "allocation"¹³ and recycling. **Therefore, for making carbon footprints comparable, it is indispensable that "Product Category Rules" (PCRs) are defined¹⁴.** Only if such rules are so stringent that every user has to choose the same [narrow range of] approaches, it will be possible to simply state a CFP as "x t CO₂e per t product", as it is needed for a credible CBAM. Without clear, credible and verifiable requirements from PCRs, the situation would be almost as if every retailer could choose the rate of VAT freely from a range given by the country's tax legislation.

¹² Even although a certain uncertainty would be result of the monitoring methodology, the CBAM – like the EU ETS – would require reporting of only one exact figure that can be equalled by a number of certificates (i.e. "123"), and not a scientifically correct reporting giving the relevant uncertainty range (e.g. 123.5 ± 0.1). Also the uncertainty range stemming from choosing certain assumptions would not be reported, as these assumptions would be laid down either in the MRV rules themselves or in the monitoring plan (if applicable) of the operator.

¹³ In the carbon footprint community, "**allocation**" is the term used for describing the fact that in case of simultaneous production of several goods, emissions of the production process must be split and assigned to the different products. A typical example is the co-production of phenol and acetone through the Hock process. However, since this document is intended for readers coming from the EU ETS perspective, where "allocation" refers to the handing out of allowances, we use in this document the term "**attribution**" of emissions to products, which is in line with the terminology of EU ETS free allocation rules.

¹⁴ ISO 14067 defines:

- 'product category': group of products that can fulfil equivalent functions;
- 'product category rules' (PCR): set of specific rules, requirements and guidelines for developing Type III environmental declarations and footprint communications for one or more product categories;
- 'carbon footprint of a product – product category rules' (CFP-PCR): set of specific rules, requirements and guidelines for CFP or partial CFP quantification and communication for one or more product categories.

2.2 Coverage of the EU ETS as basis for the CBAM

For the purpose of determining CBAM embedded emissions at product level, the starting point are emissions of an installation. In this regard, some similarities can be observed with *corporate carbon footprints* as opposed to the product carbon footprints discussed above. However, “corporation” is a possibly much bigger entity than an “installation” which is the regulated entity in the EU ETS. A corporation can include many installations in different countries, and may include various activities not included in the EU ETS. Hence, corporate environmental footprint standards¹⁵ will not match the requirements of the CBAM without further clarification of boundaries. The EU ETS’ own rules therefore need to be used as indispensable guiding principle for further discussion in this document.

The system boundaries of emissions covered by the EU ETS are narrower than those in a (corporate or product) carbon footprint. Consequently, if a carbon footprint were considered as basis for the CBAM obligation, for making it comparable to the EU ETS, the narrower of the two options would have to be applied for achieving consistency. This would come with the advantage of having boundaries which are clearly defined in robust legislation at the EU level (which means they are harmonised across all Member States¹⁶). It could also be interpreted as **the EU ETS would have to form the starting point for appropriate product category rules for the carbon footprint to be used.**

¹⁵ In particular the Commission’s OEF (Organisation Environmental Footprint, see Annexes 3 and 4 of the PEF Standard, see footnote 8); ISO 14064-1 “Greenhouse gases – Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals” or the GHG protocol corporate standard.

¹⁶ In this document, “Member States” (MS) refers to all 27 EU Member States and the EFTA countries applying the EU ETS (Iceland, Norway and Liechtenstein).

The EU ETS is a system which regulates only the *direct GHG emissions* from stationary activities (partially corresponding to “Scope 1”¹⁷) of an industrial¹⁸ installation. However, *indirect emissions* (“Scope 2”) are included in the EU ETS, insofar as the costs of allowances of electricity and other purchased energy (heating, cooling) are passed on from installations covered themselves by the EU ETS to the installation consuming this energy. The same is true for emissions included in materials consumed in an installation but produced by other installations, to the extent those are produced in installations themselves covered by the EU ETS. These materials (referred to as “**precursor materials**” in this document) would be considered to be part of “Scope 3” under the GHG protocol. However, downstream emissions (emissions from the use and end-of-life) of the products, which are also included in scope 3, are entirely outside the scope of the EU ETS. Neither are emissions included from transport of materials between sites or from processes further upstream (in particular from mining, as mining operations are usually not performed in EU ETS installations¹⁹). Figure 1 and Table 1 provide an overview of this situation.

¹⁷ The differentiation between scope 1, scope 2 and scope 3 emissions was introduced by the “GHG Protocol” (<https://ghgprotocol.org/corporate-standard>). However, the definition in particular of scope 2 is sometimes unclear (whether it includes “indirect” emissions only from electricity or also from imported heating and cooling). For the purpose of this document, we consider the definitions as given on page 28 of the “Scope 3 standard” of the GHG Protocol (<https://ghgprotocol.org/standards/scope-3-standard>) as the most useful:

- **Scope 1:** Emissions from operations that are *owned or controlled by the reporting company*, e.g. emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.; emissions from chemical production in owned or controlled process equipment.
- **Scope 2:** Emissions from the generation of purchased or acquired electricity, steam, heating, or cooling consumed by the reporting company, e.g. use of purchased electricity, steam, heating, or cooling.
- **Scope 3:** All indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions, e.g. production of purchased products, transportation of purchased products, or use of sold products.

Note: The definition of scope 1 is not restricted – as required by the EU ETS – to stationary emission sources.

A simpler concept of definitions (and possibly more compatible with CBAM needs) are the definitions by ISO 14064-01:

- **Direct GHG emission:** GHG emission from GHG sources owned or controlled by the organization;
- **Indirect GHG emission:** GHG emission that is a consequence of an organization’s operations and activities, but that arises from GHG sources that are not owned or controlled by the organization.

¹⁸ In this context, “industrial” refers not to a particular economic sector, but to the installation’s size, i.e. pilot plants or facilities at research level are excluded. Industrial installations hence include the power sector (i.e. production of electricity, heating and cooling).

¹⁹ There are a small number of installations in the EU ETS which have reported a NACE code of a mining sector. These are, however, non-typical cases. Hence the minimal advantage of non-EU mining activities staying outside the CBAM is considered justifiable.

Table 1: Comparison of scope definitions in EU ETS and proposed CBAM, compared to the ISO and GHG Protocol terms

Parameter	ISO 14064-1 (Annex B)	GHG protocol	EU ETS	CBAM ²⁰
"Direct emissions" (stationary)	Category 1	Scope 1	Subject to system boundaries of each EU ETS installation	<i>"Emissions from the production processes of goods including emissions from the production of heating and cooling consumed during the production processes, regardless of the location of the production of the heating and cooling"</i>
"Direct emissions" (mobile, e.g. forklift, cars)			Outside the scope	Outside the scope
"Indirect emissions" (upstream)				
<i>of heating/cooling imported</i>	Category 2	Scope 2	Covered if produced in an EU ETS installation	Included under "direct emissions"
<i>of electricity imported</i>				<i>"Emissions from the production of electricity, which is consumed during the production processes of goods, regardless of the location of the production of the consumed electricity"</i>
<i>of fuels imported</i>	Category 3	Scope 3		Outside the scope
<i>Transport</i>			Outside the scope	Outside the scope
<i>of (precursor²¹) materials imported</i>	Category 4		Covered if produced in an EU ETS installation	To the extent relevant precursors are defined as relevant in implementing act
"Indirect emissions" (downstream and other, e.g. use of product, end-of-life emissions)	Category 5		Outside the scope	Outside the scope

²⁰ Based on provisional text, see footnote 4.

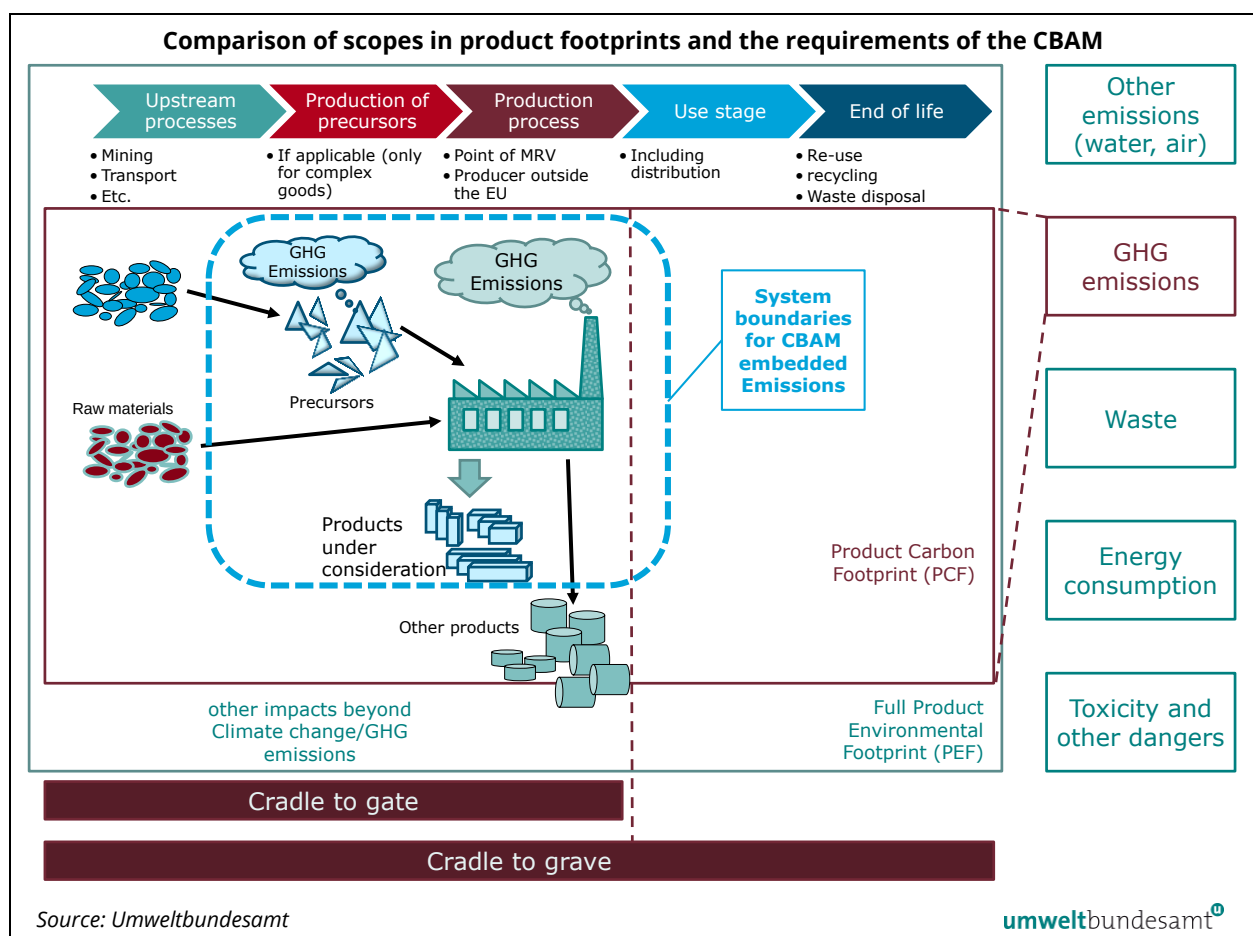
²¹ **"Precursor"** is used here within the meaning "a material (simple or complex good) which has embedded emissions other than zero, and is defined as relevant by the system boundaries of other complex goods as defined in the relevant implementing act. Consequently, mined or harvested raw materials and fuels would not fall under the definition of "precursor", and neither intermediates which would have embedded emissions not equal to zero, but which are considered insignificant for the calculation of embedded emissions of a specific good.

These considerations are reflected in the Commission proposal for the CBAM in the definitions of direct and indirect emissions, and in its Annex III which lays down the basic calculation approach, which in particular requires taking into account precursor materials. However, at this point in time, two points remain undefined:

- A political decision is to be made whether indirect emissions will be included in the calculation of the embedded emissions of goods, following a report from the Commission before the end of the CBAM transitional period and how this would take place, and
- Most technical details are to be defined later in an implementing act. This includes details on system boundaries (in particular which precursor materials are relevant), but also all kinds of requirements for the monitoring of emissions at the level of installations and the rules for attributing¹³ emissions to the different goods produced in those installations.

Note: This document serves as input to a wider discussion which aims to support the development of the said implementing act.

Figure 1: Comparison of product environmental footprint, product carbon footprint, and the specific partial carbon footprint that should be used for determining embedded emissions in the CBAM. These are basically defined by what would be covered by the EU ETS.



2.3 Compatibility of Embedded emissions and ISO 14067

As has already been stated in the introduction section, the CBAM aims at putting the imports of goods at an equal footing with goods produced under the EU ETS as far as carbon costs are concerned. As installations under the EU ETS surrender allowances for their emissions based on their annual emissions reports, CBAM importers will have to surrender CBAM certificates corresponding to the embedded emissions of the imported goods. It was argued in DG TAXUD's previous study that those *embedded emissions* are by their nature a *specific partial carbon footprint* of these goods, and that stringent *product category rules*²² will be required, to which this document aims to contribute. In this section, an attempt is made to elaborate on the compatibility between “embedded emissions” as defined in European legislation on the one hand, and a carbon footprint which is exclusively based on international standards (in particular ISO 14067). Necessary differences between these approaches will also be identified.

In line with general carbon footprint methods, work has to start by defining the *goal and scope* of the carbon footprint study. In the case of embedded emissions, the goal is to cover the same emissions that would be covered by the EU ETS, if the producer were situated in the EU. Therefore, emissions monitoring approaches should also be compatible to those of the EU ETS, as well as the methods to attribute installations' emissions to all goods produced.

As the goal is “comparability of systems”, we assess here how the requirements of Annex B (“Comparison based on the CFP of different products”) of ISO 14067 can be met by the concept of embedded emissions (Table 2).

Table 2 clearly demonstrates that by applying the requirements of ISO 14067, the rules for the CBAM must closely follow those of the EU ETS, as otherwise comparability would not be given. While this leads inevitably to a certain loss of flexibility as compared to a mere application of ISO 14067, it comes with great advantages, such as clarity of rules, and reliability in comparing data of various sources (i.e. of different producers of the same goods around the world). Nevertheless, that table also shows that the approach is overall compatible with ISO 14067. Hence, if third-party verifiers are accredited pursuant to ISO 14065 with an accreditation scope including CFP statements pursuant to ISO 14067, they could be qualified to verify also data under the CBAM Regulation (taking into account, however, that ISO 14065 is programme-neutral and requires competence for system specific rules, which would be in this case the legislation for the CBAM).

²² For some elements which have more similarities to corporate carbon footprints, “*sector rules*” would be needed.

Table 2: Requirements to ensure comparable CFP results, as applied to the development of embedded emissions rules

Requirement of Annex B of ISO 14067	How this requirement can be met in the CBAM
The following criteria shall be applied for the goal and scope definition phase:	
a) the product category definition and description (e.g. function, technical performance and use) are identical	Product categories are given by the CN code given in Annex I of the CBAM Regulation. The CN classification is well established and allows clear identification of goods. Where necessary, the implementing act pursuant to Article 7(6) may refine the classification by identifying sub-groups of the CN classes. E.g., Annex I lists CN 3102 (mineral fertilizers). The implementing act will have to set separate requirements for sub-category 3102 10 (Urea) and 3102 30 (Ammonium Nitrate), etc., because relevant production routes are different and require specification regarding system boundaries and calculation rules, etc. Furthermore this discussion note identifies in chapter 5 some sector-specific additional reporting requirements where CN-codes are not sufficient to identify product types.
b) the functional unit is identical	Functional ²³ units are not appropriate for the CBAM, but “declared units”, expressed as tonnes of product.
c) the system boundary is equivalent	The implementing act pursuant to Article 7(6) of the CBAM Regulation will serve as product category rules which define the system boundaries.
d) the description of data is equivalent	The implementing act will contain rules for monitoring and calculation methods (similar to the EU ETS Monitoring and Reporting Regulation (MRR), which allow only specific methods and set minimum requirements, making monitored emissions overall comparable across all installations.
e) the criteria for inclusion of inputs and outputs are equivalent	The criteria will be contained in the implementing act, which is legally binding. CBAM rules will reflect the rules of the EU ETS.

²³ The carbon footprint standards can be applied to compare the carbon footprint of things that can be used to achieve the same service (e.g. a hand dryer can be compared against reusable towels and disposable towels, where a “functional unit” could be defined e.g. as “10 times daily hand drying over 1 year”). For CBAM or EU ETS purposes, functional units could be e.g. “building materials for one single family house”, in order to compare the performance of bricks, concrete and wood as building materials. However, in CBAM and EU ETS such comparisons are not foreseen, as their impact would result from the carbon costs impacting the overall building costs. But the CBAM would require the emissions as “per tonne material”, which is a “declared unit” in the ISO’s vocabulary.

Requirement of Annex B of ISO 14067	How this requirement can be met in the CBAM
f) the data quality requirements (e.g. coverage, precision, completeness, representativeness, consistency and reproducibility) are the same	Requirements will be legally binding, as they will be in the implementing act. CBAM rules will reflect the MRV rules of the EU ETS.
g) assumptions especially for the use stage and the end-of-life stage are the same	Like in the EU ETS, these stages will be excluded, hence consistency is given.
h) specific GHG emissions and removals (e.g. due to LUC ²⁴ or electricity use) are treated identically	Emissions will be treated the same. The applicable values for GWP (Global Warming Potential) to calculate CO ₂ equivalents will be given in the implementing act, too (consistent with the MRR). LUC is not relevant. GHG emission abatement due to CCS and CCU as well as emissions from biomass combustion (i.e. zero-rating in the case of sustainable biomass) will be treated as in the EU ETS. Calculation rules on electricity use will be given in the act. Its treatment depends on political decisions (i.e. inclusion of indirect emissions) to be made soon.
i) the units are identical	All MRV rules for the EU ETS and the CBAM will build on the SI unit system, GWP values will be defined, etc.
The following criteria shall be applied for the life cycle inventory and LCIA ²⁵ phase:	
<i>– the methods of data collection and data quality requirements are equivalent</i>	The rules applicable for the CBAM will be developed based on EU ETS rules, hence equivalence will be ensured.
<i>– the calculation procedures are identical;</i>	
<i>– the allocation of the flows is equivalent</i>	
<i>– the applied GWPs are identical.</i>	

²⁴ Land Use Change

²⁵ Life Cycle Impact Assessment

3 MRV PRINCIPLES FOR THE CBAM

3.1 The EU ETS as a blueprint

This section is meant to give an overview of the starting point for this document – the legislative framework of the EU ETS – and to provide a central summary of relevant sources frequently cited in this document.

The legal framework for Monitoring and Reporting, Verification and Accreditation (MRVA) is provided by Articles 14 and 15, and Annexes IV and V of the **EU ETS Directive**²⁶:

- The **MRR** (Monitoring and Reporting Regulation)²⁷, which makes use of some elements of the **RED II**²⁸ regarding the sustainability of biomass;
- The **AVR** (Accreditation and Verification Regulation)²⁹.

While these Regulations concern the monitoring and reporting of emissions, further monitoring rules are found in the free allocation rules as to how to attribute those emissions to individual products. The free allocation rules therefore form an important input to this study, not least due to the rules included on splitting the installation into sub-installations for the sake of attributing emissions to the goods produced. The FAR furthermore contain a hierarchy of approaches to monitoring which may be more pragmatic than the tier system of the MRR. The approach for attributing emissions to products (or “sub-installations”) is further discussed in section 3.5.2. Relevant implementing and delegated acts are:

- The Free Allocation Rules for EU ETS phase 4 (“**FAR**”)³⁰;

²⁶ Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a system for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, amended several times. Download of the consolidated version: <https://eur-lex.europa.eu/eli/dir/2003/87/2020-01-01>

²⁷ Commission Implementing Regulation (EU) 2018/2066 of 19 December 2018 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council and amending Commission Regulation (EU) No 601/2012, consolidated version: http://data.europa.eu/eli/reg_impl/2018/2066/2022-01-01

²⁸ Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast); <https://eur-lex.europa.eu/eli/dir/2018/2001/oj>

²⁹ Commission Implementing Regulation (EU) 2018/2067 of 19 December 2018 on the verification of data and on the accreditation of verifiers pursuant to Directive 2003/87/EC of the European Parliament and of the Council, Consolidated version: http://data.europa.eu/eli/reg_impl/2018/2067/2021-01-01

³⁰ 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, http://data.europa.eu/eli/reg_del/2019/331/oj

- **ALC** (Allocation Level Change) Regulation³¹;
- The “carbon leakage list” for phase 4 of the EU ETS³²;
- Benchmark values for phase 4 of the EU ETS³³;

Guidance material referred to in this document can be found here:

- Guidance on MRR and AVR: https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets/monitoring-reporting-and-verification-eu-ets-emissions_en
- Guidance on benchmarking and free allocation rules: https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets/free-allocation_en
- Guidance on the interpretation of the scope of the EU ETS: https://ec.europa.eu/clima/system/files/2016-11/guidance_interpretation_en.pdf

3.2 Definitions

Because the definitions of “scope 1, 2 and 3” do not match well the needs of the CBAM, the Commission proposal uses the terms “direct emissions” and “indirect emissions”. The definitions were slightly modified thereafter, and the agreed CBAM Regulation uses the following definitions, which are in line with how they are used throughout this document:

‘direct emissions’ mean emissions from the production processes of goods, including emissions from the production of heating and cooling consumed during the production processes, regardless of the location of the production of the heating and cooling.

‘indirect emissions’ mean emissions from the production of electricity, which is consumed during the production processes of goods, regardless of the location of the production of the consumed electricity.

Note that these definitions provide clarity in terms of electricity being itself a product which has its own “attributed emissions” (compare section 3.5.2). Furthermore the term “embedded emissions”, as understood for the purpose of this discussion note, could be defined as follows:

³¹ Commission Implementing Regulation (EU) 2019/1842 of 31 October 2019 laying down rules for the application of Directive 2003/87/EC of the European Parliament and of the Council as regards further arrangements for the adjustments to free allocation of emission allowances due to activity level changes http://data.europa.eu/eli/reg_del/2019/331/oj

³² 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; http://data.europa.eu/eli/dec_del/2019/708/oj

³³ Commission Implementing Regulation (EU) 2021/447 of 12 March 2021 determining revised benchmark values for free allocation of emission allowances for the period from 2021 to 2025 pursuant to Article 10a(2) of Directive 2003/87/EC of the European Parliament and of the Council, http://data.europa.eu/eli/reg_impl/2021/447/oj

‘embedded emissions’ mean direct emissions released during the production of goods and indirect emissions from the production of electricity consumed during the production processes, calculated in accordance with the methods set out in Annex III and further specified in the implementing acts adopted pursuant to Article 7(6).

The reference to the implementing act pursuant to Article 7(6) effectively means that precursors are to be taken into account for the calculation of embedded emissions where they are explicitly defined as relevant within that implementing act. For the purpose of this discussion note we implicitly use the following definition (not contained in the CBAM Regulation):

‘Relevant precursor material’ means a simple or complex good which has embedded emissions not equal zero when applying the methods set out in Annex III, and which is identified [in the implementing act pursuant to Article 7(6)] as being within the system boundaries for the calculation of embedded emissions of a complex good.

3.3 General principles

All MRV systems apply certain principles, whether they are mentioned explicitly in their applicable rule books or not. In this section we list principles which should be applied for the monitoring, reporting and verification of embedded emissions in the definitive period of the CBAM. To the extent possible, they should also apply in the transitional phase.

The proposed principles go partly back to IPCC guidelines for preparation of national GHG inventories, but are presented here with the meaning they are given by the MRR for the EU ETS. Some further principles are added for taking into account the carbon footprint nature of embedded emissions, taking into account ISO 14067, and additional ones for making the EU ETS and CBAM as comparable as possible.

1. [MRR] **Completeness:** For achieving consistency with the EU ETS, an installation that produces goods to be exported to the EU and falling within the scope of the CBAM, the operator of that installation will have to define the installation boundaries, and in particular the list of relevant “source streams” as complete as required under the EU ETS. “Source streams” means fuels and raw materials which lead to GHG emissions during the process, and therefore have to be monitored in quantity and quality. An exception may be possible for source streams which are not used for the production of goods falling under the CBAM (e.g. if an installation produces fertilizers and other inorganic chemicals, the processes for the other chemicals do not have to be monitored, provided the quantities of source streams used in fertilizer production can be accurately determined).

The second aspect of completeness is that the system boundaries set in the implementing act for each good’s embedded emissions need to be applied. This will cover the relevant processing steps and relevant precursor materials.

As a third aspect, completeness should also be read as “avoiding double counting” of the same emissions.

2. [MRR] **Consistency and comparability:** MRR Guidance Document No.1 (“GD1”)³⁴ elaborates: *“Time series³⁵ of data need to be consistent throughout the years. Arbitrary changes of monitoring methodologies are prohibited. This is why the monitoring plan (MP) has to be approved by the competent authority, such as also significant changes to the MP. Because the same monitoring approaches are defined for all installations, from which they may choose using the tier system, the data created is also comparable between installations.”* Note that for the CBAM, it is not yet decided if monitoring plans will be required, but having an MP in place (even if on a voluntary basis) can be considered best practice for applying this principle and strongly simplifies verification. However, the legislation will have to ensure that CBAM embedded emissions are comparable to the EU ETS emissions, and **prevent operators from making arbitrary choices** that result in lower embedded emissions. To ensure comparability, the specific EU ETS provisions on CCU/CCS and biomass combustion need to be taken into account to the extent possible.
3. [MRR]: **Transparency:** GD1 explains: *“All data collection, compilation and calculation must be made in a transparent way. This means that the data itself, the methods for obtaining and using them (in other words: the whole data flow) have to be documented transparently, and all relevant information has to be securely stored and retained allowing for sufficient access by authorised third parties. In particular, the verifier and the competent authority must be allowed access to this information.*
It is worth mentioning that transparency is in the own interest of the operator: It facilitates transfer of responsibilities between existing and new staff and reduces the likelihood of errors and omissions.”
4. [MRR] **Accuracy:** GD1 states: *“Operators have to take care that data is accurate, i.e. neither systematically nor knowingly inaccurate. Due diligence is required by operators, striving for the highest achievable accuracy.”* For operationalising this concept, the MRR contains rules on different tiers of data quality, and defines minimum tiers to be used. The improvement principle (see below) is translated into “striving to reach higher tiers”.
For the purpose of the CBAM, where many operators will start monitoring from scratch and possibly with limited resources, rules for achieving a reasonable accuracy balanced against feasibility in practice will have to be developed carefully.
5. [MRR] **Integrity of methodology:** The data shall provide a credible and balanced account of an installation’s emissions (in case of CBAM: of the embed-

³⁴ MRR Guidance Document No.1 (“General guidance for installations”),
https://ec.europa.eu/clima/system/files/2022-02/gd1_guidance_installations_en_0.pdf

³⁵ This does not imply a requirement to produce time series of data, but assumes that the operator, verifier or competent authority may use time series as a means of consistency checks.

ded emissions of a good). The monitoring methodology and the data management must allow the verifier to achieve reasonable assurance³⁶ on the emissions report, i.e. the data must be able to endure intensive tests. Data shall be free from material misstatements³⁷ and avoid bias.

6. [MRR] **Continuous improvement:** As the introduction of the CBAM is planned to happen relatively fast, it will be no surprise if at the beginning operators will not be fully prepared to carry out all the necessary monitoring steps at the highest possible quality. For avoiding unreasonable costs, monitoring will sometimes include the need to fall back to default values, literature data, proxy data or estimations. Nevertheless, technological progress may provide better and/or cheaper metering equipment in the future, and verification will help to improve internal control systems, based on improved identification of risks in the data flows. The CBAM legislation should provide either incentives or a legal requirement to regularly revise the applied monitoring methods with the aim of improving them.
7. **Value chain:** While ISO 14067 applies the principle of “life cycle perspective”, meaning that all stages (from acquisition of raw materials to end-of-life, see section 2.1) should be taken into account, the CBAM requires that only explicitly identified precursor materials have to be taken into account when determining embedded emissions, and the emissions downstream are not taken into account.
8. **Use best available data sources:** ISO 14067 applies the principle “Priority of scientific approach” meaning *“Preference to natural science (such as physics, chemistry, biology) is given when making decisions in the CFP study. [...]”*. The MRR at several places provides a hierarchy of approaches such as the first the use of *“EN standards. Where such standards are not available, the methods shall be based on suitable ISO standards or national standards. Where no applicable published standards exist, suitable draft standards, industry best practice guidelines or other scientifically proven methodologies shall be used, limiting sampling and measurement bias.”*
The free allocation rules (Annex VII) defines a hierarchy of preferred approaches (starting from the most preferred option) as follows:
 - a. Methods in accordance with the monitoring plan approved under the MRR;

³⁶ The AVR defines: *“‘reasonable assurance’ means a high but not absolute level of assurance, expressed positively in the verification opinion, as to whether the operator’s or aircraft operator’s report subject to verification is free from material misstatement.”* For more details on the definition this term, see the AVR Explanatory Guidance (EGD I), https://ec.europa.eu/clima/system/files/2022-02/exp_guidance_1_en.pdf

³⁷ See the guidance document referred to in footnote 36.

- b. Readings of measuring instruments subject to national legal metrological control³⁸ or measuring instruments compliant with certain EU legislation³⁹ for direct determination of a data set;
- c. Readings of measuring instruments under the operator's control for direct determination of a data set not falling under point (b);
- d. Readings of measuring instruments not under the operator's control for direct determination of a data set not falling under point (b);
- e. Readings of measuring instruments for indirect determination of a data set, provided that an appropriate correlation between the measurement and the data set in question is established;
- f. Other methods, in particular for historical data or where no other data source can be identified by the operator as available.

The use of best available data sources also means a need to keep up to date with scientific progress. Specifically, GWP values are regularly revised by the IPCC. EU legislation in the field of climate change requires the use of GWP values of the 5th Assessment Report by the IPCC (AR5) (see Table 3). In general, compatibility with IPCC 2006 Guidelines (with the 2019 refinement) is required. GWP values in the CBAM should only be adjusted when this is done also in other fields of climate policies, and when in accordance with international agreements.

Table 3: Global Warming Potential (GWP) values given by the MRR, in line with the IPCC 5th assessment report (AR5)

Gas	Global warming potential
N ₂ O	265 t CO ₂ (e) / t N ₂ O
CF ₄	6 630 t CO ₂ (e) / t CF ₄
C ₂ F ₆	11 100 t CO ₂ (e) / t C ₂ F ₆

9. [GHG Protocol] **Representativeness:** When using data other than actual data from the operator's measurements (e.g. data of embedded emissions of purchased precursor materials), data used must be representative in terms of *technology, time, geography, completeness and reliability*. This will be e.g. important for selecting the appropriate default values. On another occasion, the MRR requires representativeness in particular for any sampling for the purpose of carrying out laboratory analyses.
10. **Equal treatment** of energy and material flows, whether or not they originate from within the operator's own installation or are purchased. Emissions under the EU ETS and under the CBAM should also be considered equal. This

³⁸ For readers outside the EU, "metering under legal metrological control" can be translated to "fiscal metering", meaning "Quality controlled metering used for invoicing of fuels such as oil and gas. The control process is usually part of legislation for national metrological control.", see PMR: "Developing Emissions Quantification Protocols for Carbon Pricing – A Guide to Options and Choices for Policy Makers"; <https://openknowledge.worldbank.org/handle/10986/34388>

³⁹ Measurement Instruments Directive (Directive 2014/32/EU) and Non-automatic weighing instruments Directive (Directive 2014/31/EU)

principle has the following impacts on the rules for embedded emissions to be developed:

- a. The emissions from the production of heating and cooling must be included in the direct emissions of production processes, no matter whether they are produced inside the installation or imported from another installation, and independently from whether they are produced in dedicated boilers, CHP installations or as process (recovered waste) heat from other production processes. In turn, emissions from production of heat exported to other users (including to the production of other products within the same installation) must not be taken into account, in order to prevent their double counting.
- b. For those goods⁴⁰ for which the political decision was made to include indirect emissions (i.e. emissions from the production of electricity consumed in the process) in the scope of the CBAM, the same rule as under point (a) applies to emissions from electricity production. However, with regards to exports of electricity from the installation, the related emissions must never be included in the embedded emissions of CBAM goods (since electricity itself is a “good”).
- c. Embedded emissions of precursor materials have to be determined using the same rules no matter if they are produced in the same installation, purchased from other installations, or sold to other installations.

This means that the user of a precursor material has to request data on the embedded emissions from the producer, applying the same CBAM rules (and having the same level of verification), even if that producer does not itself export materials to the EU. The producer of a precursor material can also be an EU producer.

- d. Where precursor materials originate in jurisdictions with a carbon price, not only the embedded emissions, but also the relevant information on the effective carbon price already paid has to be reported, so that it can be deducted from the CBAM obligation. In the case where an EU producer exports precursor materials, this effective carbon price will be the costs for purchased allowances attributed to this material (i.e. the difference between actual emissions and free allocation received).

3.4 Generic monitoring methods

GHG emission monitoring at the level of installations is carried out in many jurisdictions around the world for the purpose of carbon pricing (ETS or carbon taxes), for creating (voluntary or regulated) offset credits (as in the UN Clean Development Mechanism (CDM) or the Voluntary Carbon Standard (VCS)), or for

⁴⁰ According to the provisional political agreement, indirect emissions are included in the CBAM only for some of the goods listed in Annex I. Those goods are listed separately in a second annex.

other purposes (such as general environmental reporting or for raising certain claims, such as carbon footprints or product labelling). As all approaches are in some way linked to the IPCC inventory rules and to natural sciences in general, monitoring approaches are not too different overall concerning their general functioning. Therefore, although the following is based on the EU ETS rules, the general approaches will be well understood in other jurisdictions as well.

3.4.1 Calculation methods

In many processes (e.g. combustion), it is known that each atom of carbon will become one molecule of CO₂ (i.e. the stoichiometry is well-defined). It is therefore enough to know the amount of the material used and the concentration of carbon contained therein. The latter is usually expressed as an “emission factor”. Incomplete reactions (which can be determined by analysing the carbon content of the products and residues other than the emitted gases) can be taken into account by a correction factor (called “oxidation factor” for combustion emissions, or “conversion factor” for process emissions). If there are several products which contain carbon (e.g. in steel production or organic chemical syntheses, production of carbon black etc.) it is simpler to apply a “mass balance”, which sums up all carbon in inputs minus all carbon in outputs other than emissions⁴¹. The difference in carbon content multiplied by the ratio of the molecular weights of CO₂ and carbon is then equal to the CO₂ emissions. Table 4 presents the relevant formulae for each single source stream, and lists the relevant parameters.

Table 4: Formulae for calculation methods in emissions monitoring

Fuels	Process materials	Mass balance
$Em = AD \cdot EF \cdot OF$	$Em = AD \cdot EF \cdot CF$	$Em = \sum_i f \cdot AD_i \cdot CC_i$
Where:		
Em ...Emissions [t CO ₂]		
AD ...Activity data [TJ] $AD = FQ \cdot NCV$	AD ...Activity data [t of material]	AD_i ...Activity data [t of material i]; for outputs, AD_i is negative
Where FQ ... Fuel quantity [t or m ³] NCV ... Net Calorific value (lower heating value) [TJ/t or TJ/m ³]		f ...ratio of molar mass of CO ₂ to C $f = 3.664 \text{ t CO}_2/\text{t C}$
EF ...Emission factor [t CO ₂ / TJ]	EF ...Emission factor [t CO ₂ / t]	CC_i ...carbon content of material i (dimensionless and positive)
OF ...Oxidation factor (dimensionless)	CF ...Conversion factor (dimensionless)	
$OF = 1 - C_{ash}/C_{total}$		

⁴¹ The aforementioned approach of determining emissions through activity data and emission/oxidation/conversion factors is actually also based on the principle of mass conservation and one could call this a simplified mass balance. However, the MRR refers to mass balances only when referring to the carbon contents of all input and output materials.

C_{ash} ...Carbon contained in ash and slags; C_{total} ...Total carbon in fuel

3.4.2 Measurement methods

The alternative to calculation is the use of CEMS (Continuous Emissions Measurement Systems). These have advantages where emissions resulting from many different source streams can be measured in one single stack. Their disadvantage is that they require sophisticated calibration and maintenance, and either redundant systems or a second method for filling data gaps in cases where CEMS are out of operation or out of calibration.

CEMS consist of two parts: Measurement of the flow rate of the exhaust gas, and measurement of the concentration of the greenhouse gas under consideration. Both parameters have to be measured continuously, and the value (concentration times flow) is integrated over time. For periods where one of the measurements malfunctions, proxy values or values from another measurement have to be used.

The result of such measurements is an overall figure of emissions over the whole reporting period (e.g. year), covering potentially many source streams (e.g. different fuels). However, where there are other emission sources in the installation, they must be either monitored with a similar CEMS approach, or the remaining emissions are determined using a calculation approach.

3.4.3 Other methods

In the EU ETS, the MRR allows so-called fall-back approaches for the very rare cases where an installation has neither calculation nor measurement approaches at hand which meet the minimum criteria. These would usually be some kind of indirect measurement or model-based calculations. Operators must demonstrate that the applied method meets the required uncertainty level.

According to the PMR guide⁴², some carbon pricing systems (outside the EU ETS) allow furthermore the use of "Predictive Emissions Monitoring Systems" (PEMS⁴³), e.g. *"the US EPA federal regulations on emissions monitoring allow PEMS under certain conditions including the demonstration by the facility that the PEMS has the same or better precision, reliability, accessibility, and timeliness as an approved CEMS"*. For the purpose of the CBAM, it appears desirable that a wide

⁴² "Developing Emissions Quantification Protocols for Carbon Pricing – A Guide to Options and Choices for Policy Makers"; <https://openknowledge.worldbank.org/handle/10986/34388>

⁴³ According to the PMR guide (Footnote 42), PEMS is *"A software-based alternative to a CEMS, typically used as a backup system. This system uses software analysis to provide a real time estimation of emissions properties by using an advanced mathematical model of the emissions generating process based on real process values such as temperature, pressure, and flow."*

range of monitoring systems are allowed, so that the MRV requirements are no obstacle for the valid generation of actual data. Therefore, PEMS should be considered to be allowed.

3.4.4 PFC emissions (Aluminium production)

For the monitoring of PFCs (perfluorocarbons), the MRR uses the indirect determination methods (based on correlations) developed by the International Aluminium Institute, which are based on the monitoring of periods of anode effects (overvoltage) in the electrolysis, using emission factors that are regularly calibrated by emission measurements. Only the gases CF_4 and C_2F_6 are taken into account. This approach is in line with the IPCC guidelines.

3.4.5 N_2O emissions

N_2O emission levels in nitric acid production depend on the production conditions and the performance of the end-of-pipe abatement equipment. There is no stoichiometric relationship that can be used for a calculation approach. Therefore, only CEMS are allowed for N_2O monitoring. For CBAM purposes, CEMS are therefore important in particular in the fertilizer industry (but not limited to it).

3.4.6 Transfer of CO_2 between installations

CO_2 can be transferred between installations in two situations:

- When CO_2 is contained in a gas which can be used as fuel due to its energy content (e.g. as constituent of blast furnace gas transferred to a power plant), the MRR terms this “inherent CO_2 ”. There are clear rules for accounting, e.g. by applying a mass balance approach: The CO_2 exported does not count as emission of the producing installation, and the receiving installation adds the CO_2 to its own emissions by taking it into account for the emission factor of the gas. Hence the “direct emitter” principle is applied.
- CO_2 can be transferred between installations either for using the CO_2 as process input (e.g. for the production of urea, or precipitated calcium carbonate (PCC), etc.⁴⁴), or for the purpose of CCS (Carbon Capture and [geological] storage). In this case the amount of CO_2 transferred has to be monitored using continuous measurement.

⁴⁴ There are currently many ongoing projects for the development of CCU (Carbon Capture and Utilisation), e.g. for the production of “eFuels” (i.e. fuels which will be produced from captured CO_2 and hydrogen from electrolysis with renewable electricity). However, the legal implementation of monitoring rules is currently pending, as it will first require adoption of the “Fit for 55” amendments to the EU ETS Directive.

It will be necessary to use the same approaches for determining embedded emissions under the CBAM.

3.4.7 Methods for heat measurement

As the definition of “direct emissions” includes emissions caused by heat production where heat may be produced outside the production process, it is necessary to define rules for monitoring heat quantities. The monitoring rules of the free allocation rules distinguish “measurable heat” and “non-measurable heat”:

- **Non-measurable heat** is generated directly in a production process, e.g. where fuels are combusted in a dryer or kiln, and the heat is directly transferred to the materials that are intended to be heated. In such case there is no heat measurement possible, and only the amount of energy input by the fuels is used for calculation, if needed. Such heat is unlikely to be transferred between installations⁴⁵.
- **Measurable heat:** This is heat transported by a heat transfer medium (steam, hot air, hot water, molten salts, etc.) through defined pipes or ducts. In this case, the heat can be measured by determining the heat content (enthalpy) of a unit (e.g. 1 m³) of heat transfer medium, multiplied by the measured flow rate of the medium.

For measurable heat, the FAR (and supporting guidance documents⁴⁶) provides several monitoring rules. Heat flows must be calculated as *net* heat flows (i.e. subtracting heat contained in returned heat transfer medium. Where condensate from steam is not returned, default assumptions have to be made). Furthermore a specific method is given for attributing emissions to heat and electricity, respectively, if CHP (Combined Heat and Power, also called “Cogeneration”) is applied. Similar rules will be required for the CBAM.

3.4.8 Electricity measurement

Electricity measurements will be required for two reasons under the CBAM: If electricity is produced by an installation which has to determine embedded emissions of a product, electricity is also a kind of product to which a part of the installation's emissions have to be attributed. Secondly, if indirect emissions have to be included in the embedded emissions, the quantity of electricity consumed in a production process has to be measured.

⁴⁵ An exception may be e.g. the rare case where preheated intermediates are transferred between installations of the steel industry. However, in this case the intermediates can be considered a heat transfer medium, i.e. the case can be treated like “measurable heat”.

⁴⁶ In particular Guidance document 5 (“Guidance on Monitoring and Reporting in Relation to the Free Allocation Rules”): https://ec.europa.eu/clima/system/files/2019-02/p4_gd5_mr_guidance_en.pdf

Since electricity measurements in general are very accurate and non-problematic (often covered by legal metrological control), the EU ETS has few provisions for this purpose. Only the guidance document⁴⁶ contains some points to be taken into account: *“Metering should apply to real power, not apparent power (complex power). I.e. only the active power component should be metered, and the reactive power should be disregarded”*.

For appropriate accounting for renewable energy, it will be necessary to address the issue of *“location-based accounting”* vs. *“market-based accounting”* (acknowledgement of the purchase of green electricity if specific requirements addressing the contractual arrangements are met) here as well. Here the requirements really differ between ISO 14067, ISO 14064-1, GHG Protocol and PEF/OEF. However, this is outside the scope of this project.

3.4.9 Quantities of materials and goods

All quantities on imports of CBAM goods into the EU for determining the CBAM obligation will be expressed as (metric) tonnes. For certain goods, the imported quantities need to be converted to standardised tonnes that are subsequently used for calculating the CBAM obligation. For example, for nitric acid, hydrous solutions of ammonia and nitrogen-containing fertilizers, there will be a need to explicitly state the reference concentration / nitrogen content (and form of nitrogen). These definitions will have to be contained in the implementing acts for the CBAM.

Where quantities of precursor materials have to be determined, some additional rules may be necessary (e.g. how to treat internal recycling).

3.5 Calculation rules

In principle, there are two ways of arriving at embedded emissions: The starting point could be the product to be imported, which would be traced through the value chain until all emissions from all previous production steps are added up (bottom-up approach). The other option is to start from the installation level, and to split those emissions such that they are attributed to different products and by-products (top-down). To those emissions, further emissions are added for precursor materials, which have been determined by a similar process (either by the same operator or a different one).

In practice, it is usually relatively simple to monitor the total emissions of a defined installation, since there is usually one main metering device for each fuel which is used in the whole installation, whereas there are less often sub-meters which allow the split of fuel quantity to individual production processes. Also steam is usually produced centrally and distributed to different processes. It is therefore more common practice to apply the top-down approach. In particular, the top-down approach is used in the EU ETS (where emission attribution is needed to determine the benchmark values). The Commission proposal for the

CBAM Regulation (in Annex III) builds on these principles already known from the EU ETS.

In this chapter we therefore summarize the relevant calculation approach based on the CBAM Regulation and related EU ETS legislation.

3.5.1 Step 1: Determine installation's emissions

Under section 3.4, the different methods for monitoring have been summarized. As the emissions at installation level can be monitored by different approaches, which can also be combined, provided that neither gaps nor double counting occur, a formula for the total emissions of an installation can be:

$$Em_{Installation} = \sum (calculated\ emissions\ of\ all\ source\ streams) + \sum (measured\ emissions\ of\ all\ emission\ sources) + \sum (emissions\ determined\ by\ other\ methods,\ e.\ g.\ PEMS)$$

Note: If all “attributed emissions” (see next step) of all goods produced in one installation are added, these attributed emissions will not necessarily add up to the same number as the emissions determined using the formulae above. This is because the installation may produce electricity or heat that is exported to other installations, or import heat from other installations or electricity from the grid or from specific installations. These elements add to the calculation of attributed emissions.

As the definitions of “direct” and “indirect” emissions are tailor-made for the purpose of deciding whether electricity-related emissions should be taken into account or not, it is also impossible to state just that “the total emissions of an installation are its direct emissions”. Therefore, in this section we will refer to “the installation's emissions” when we mean “everything for which an installation would have to surrender allowances, if it were included in the EU ETS”, which is identical to the result of the formula above.

3.5.2 Step 2: Attribute emissions

Once the total emissions of an installation have been determined, the operator has to split the emissions according to the goods produced. In this step, this is done without considering embedded emissions of precursor materials used. Instead, each good is considered a “simple good”, i.e. only the (direct and/or indirect) emissions from only one production process is taken into account. If an installation produces also some precursor materials, they are considered separately as individual goods themselves.

At this stage the aim is to attribute 100% of the installation's emissions to goods⁴⁷, without gaps and double counting. Note that in this context “electricity” and “heat” are also “goods” (they have an economic value and can be traded). Also goods which are not covered by the CBAM have to be considered in order to reach this 100% target. In order to satisfy the CBAM Regulation's definition of “direct emissions”, heat imported must be taken into account (i.e. added to the installation's total emissions). For the goods where also “indirect emissions” are covered⁴⁸, electricity imports have to be added to the installation's total emissions. In this section, we discuss direct and indirect emissions separately.

Note that the approach to “attributed emissions” for the CBAM may be different in the end than the attributed emissions under the EU ETS free allocation rules. This is in particular due to two reasons:

- In the EU ETS for the purpose of determining the benchmarks for free allocation, electricity consumed in a production process is taken into account only in very specific situations (i.e. where heat stemming from fuels can be directly substituted by heat from electricity; these processes are marked in Annex I of the FAR). Otherwise there is no need to report electricity consumption. In the CBAM, the inclusion of electricity-related emissions depends on whether or not indirect emissions have to be taken into account. If to be taken into account, *all* electricity consumption would be relevant in the production of the specified goods covered by the CBAM, not only the part which is defined as exchangeable according to the FAR. On the other hand, for goods in the CBAM without need to include indirect emissions, not even the “exchangeable part” of electricity consumption would be included in the attributed emissions.
- Since the EU ETS knows only a limited number of different products (those that have a dedicated product benchmark), other processes are assigned to “fall-back approaches”⁴⁹. However, the production of goods under the CBAM may include some processes which relate to these fall-back approaches (e.g. the step from crude steel to hot-rolled steel products would usually fall within the “fuel benchmark” sub-installation). It remains to be discussed how the system boundaries should be set in the CBAM for each process. In this example hot rolling could be included in one step with the production of crude steel, or there could be two separate processes, in which case crude steel could be the precursor material for hot-rolled steel.

Note: The approach to handle different production processes as outlined in chapter 5 builds on the assumption that each production process could be treated like a sub-installation under the EU ETS (see below section 3.5.2.1). However, installations exist which operate several of the outlined production

⁴⁷ Note that in the FAR there are some exceptions to the 100% rule, e.g. where emissions from flaring are taking place. For the CBAM, this exception may not be applicable.

⁴⁸ See footnote 40.

⁴⁹ Heat benchmark, fuel benchmark and process emissions.

routes simultaneously, with various degrees of overlap. In order to keep complexity manageable and to avoid a potential source of circumvention, it is proposed that the methodology for calculating embedded emissions should apply **a single level of embedded emissions to similar products produced by different production routes within the same installation**. This single level should be the weighted (annual) average embedded emissions of all similar products across different production routes within the same installation.

For example, if in one installation liquid steel is produced both in blast furnaces and in electric arc furnaces, the weighted average of both production routes should be applied.

3.5.2.1 Attributed Emissions in the EU ETS

As a starting point, the formula for determining attributed emissions of a product (or rather of a “sub-installation” to which a product benchmark relates) is taken from the EU ETS benchmarking principles for free allocation, as described in GD5⁴⁶:

$$\begin{aligned} \text{AttrEm} = & \text{DirEm}^* + \text{Em}_{H,\text{import}} - \text{Em}_{H,\text{export}} + \text{WG}_{\text{corr},\text{import}} - \text{WG}_{\text{corr},\text{export}} \\ & + \text{Em}_{\text{el},\text{exch}} - \text{Em}_{\text{el},\text{produced}} \end{aligned}$$

The variables of this equation are explained as follows:

AttrEm: Attributed emissions of the sub-installation.

DirEm* Directly attributable emissions⁵⁰ as linked to source streams of the MP under the MRR, with the following exceptions:

- Measurable heat: Where fuels are consumed for the production of measurable heat which is consumed outside the sub-installation, or which is used in more than one sub-installation (which includes situations with imports from and exports to other installations), the fuels’ emissions are not included in the directly attributable emissions of the sub-installation, but added under the parameter $\text{Em}_{H,\text{import}}$. This approach is necessary in order to avoid double counting.

⁵⁰ The alternative term “direct emissions” could be perceived confusing, as the term is used differently in the CBAM context, and in the FAR the term is used only in the context of electricity exchangeability. Hence, the term is here used in a very specific way for the purpose of this formula only. This is the reason why it is designated with an asterisk (*) to highlight the specific meaning.

- For waste gases⁵¹ special rules apply in the EU ETS. They are taken into account as listed under the “WG” terms below.

Em_{H,import} Emissions related to the attribution of measurable heat imported to the sub-installation. This includes imports from other installations, other sub-installations as well as heat received from a technical unit (e.g. a central power house at the installation, or a more complex steam network with several heat producing units) that supplies heat to more than one sub-installation.

Emissions from heat imported are calculated either using the emission factor of the actual known fuel mix, or using a default value for the specific emissions of heat (the so-called heat benchmark value). There are some cases in which zero emissions are attributed to the heat (e.g. where it comes from the production of nitric acid, or when produced from electricity (e.g. in thermomechanical pulping)).

Em_{H,export} Emissions related to the attribution of measurable heat exported from the sub-installation. Always determined based on the heat benchmark value.

WG_{corr,import} Correction for imported waste gases: Under the MRR, the direct emitter is fully responsible for reporting the emissions and surrendering the corresponding allowances. This would mean that a unit that combusts a waste gas has to report the full emissions of the waste gas. However, for the purposes of free allocation, emissions of waste gases are split between the producing and the consuming sub-installation. For the import, i.e. use of the waste gas, the relevant attributable emissions are calculated as:

$$WG_{corr,import} = V_{WG} \cdot NCV_{WG} \cdot BM_F$$

where V_{WG} is the volume of the waste gas imported, NCV_{WG} its net calorific value, and BM_F the fuel benchmark (some exceptions apply, see GD5⁴⁶).

WG_{corr,export} Correction for exported waste gases: Where a waste gas is produced in the sub-installation, its full emissions are already included in the sub-installation's attributed emissions, as a consequence of the source streams included in *DirEm**. Therefore a correction is only required for any volume exported⁵². For the export (i.e. use of the waste gas elsewhere), the relevant attributable emissions to be subtracted are calculated as

$$Em_{WG} = V_{WG,exported} \cdot NCV_{WG} \cdot EF_{NG} \cdot Corr_{\eta}$$

where $V_{WG,exported}$ is the volume of waste gas exported from the sub-installation, NCV_{WG} is the net calorific value of the waste gas, EF_{NG} is the emission factor of

⁵¹ Waste gases are defined in the FAR as follows: “‘waste gas’ means a gas containing incompletely oxidised carbon in a gaseous state under standard conditions which is a result of any of the processes listed in point (10) [i.e. in the definition of the process emissions sub-installation], where ‘standard conditions’ means temperature of 273,15 K and pressure conditions of 101 325 Pa defining normal cubic metres (Nm³) [...]”.

⁵² The correction takes into account that the consumer of the waste gas should be put on equal footing with other installations using natural gas, and correcting for the two different efficiencies typical for the use of the gases.

natural gas, and $Corr_\eta$ is a factor that accounts for the difference in efficiencies between the use of waste gas and the use of the reference fuel natural gas.

$Em_{el,exch}$ In the EU ETS, this refers to emissions equivalent to the “exchangeable”⁵³ electricity quantity (relevant only in the determination of the benchmarks). For the purpose of the CBAM, this factor can either be omitted (if only direct emissions are to be taken into account), or replaced by the emissions of the total consumed electricity (if indirect emissions of the relevant good are included in the scope of the CBAM). This emission part is calculated as

$$Em_{el,exch} = El_{cons,exch} \cdot EF_{El}$$

Where $El_{cons,exch}$ is the amount of exchangeable electricity (or the total electricity, see above) consumed, and EF_{El} the relevant emission factor of electricity. For the FAR, $EF_{El} = 0.376 \text{ t CO}_2 / \text{MWh}$ (based on the average EU electricity mix in the reference year). For CBAM purposes, specific rules for setting that emission factor need to be developed (e.g. using national or regional fuel mixes of the installation's country).

$Em_{el,produced}$ Emissions equivalent to the electricity produced in a sub-installation. The same emission factor is to be used as for imported electricity (see $Em_{el,exch}$ above).

3.5.2.2 Attributed direct emissions

The Commission proposal (Annex III, section 2) states simply that only direct emissions should be taken into account⁵⁴:

$$AttrEm_g = DirEm$$

Where DirEm are the direct emissions, resulting from the production process, expressed in tonnes of CO₂e, within the system boundaries referred to in the implementing act pursuant to Article 7(6)."

Hence, it would be left to the said implementing act (to which this note should contribute) to provide more detailed interpretation of what emissions to include. Without such further details, the formula of Annex III is not as precise as outlined under 3.5.2.1. Applying that section (and in particular using the logic of differentiating the total emissions of an installation and its direct emissions), and under the assumption that no indirect emissions (i.e. emissions from electricity consumption) should be included, the formula should read more precisely as follows:

$$AttrEm = DirEm^* + Em_{H,import} - Em_{H,export} + WG_{corr,import} - WG_{corr,export} - Em_{el,produced}$$

⁵³ This factor applies only in cases explicitly identified in the FAR. This is the case where some installations use electricity for heating, while others use fuels, e.g. some furnaces in glass or the steel industry, some compressors/turbines in fertilizer industry, etc.

⁵⁴ At this stage, Emissions are not yet expressed as “per tonne of product”, but e.g. at the level of annual emissions of the installation.

Note that at the current stage it is not clear yet if the two terms regarding waste gases can be omitted. If omitted, the method would be strongly simplified, but it would come at the cost of clearly unequal treatment of CBAM imports and products under the EU ETS, in particular for the blast furnace route of steel production. It would require a political decision whether such unequal treatment would be acceptable (as higher emissions would be attributed to steel production, this could be considered an unfair trade barrier).

3.5.2.3 Attributed indirect emissions

For the purpose of the transitional period of the CBAM, indirect embedded emissions have to be reported separately from the direct embedded emissions. In the definitive phase, according to the provisional political agreement, only for some goods indirect emissions will have to be reported⁴⁰. For calculating these, it will be necessary first to calculate attributed indirect emissions as⁵⁵:

$$AttrEm_{indir} = Em_{el,consumed}$$

Where $Em_{el,consumed}$ is the emissions caused by the production of electricity consumed in the production process. Where the fuel mix of electricity production is known (in particular if it is produced in the same installation, or a directly connected power plant), the true fuel mix emission factor should be used. For electricity stemming from the grid, the emission factor should be used which is defined for this purpose (note: this will be analysed in a different project). The national or regional fuel mix emission factor would be a good candidate for this purpose.

3.5.2.4 Total attributed emissions

For those goods for which both direct and indirect emissions are to be applied in the CBAM for determining embedded emissions, the result is⁵⁵

$$AttrEm_{total} = AttrEm + AttrEm_{indir}$$

This formula is now included in the CBAM Regulation after the political proposal. For avoiding a repetitive discussion, **below we will always use only “AttrEm” in formulae**. However, for those goods where indirect emissions are to be included in the CBAM, the same formulae would still work by just substituting $AttrEm_{total}$ for $AttrEm$.

⁵⁵ Footnote 54 applies here, too.

3.5.3 Step 3: Normalize attributed emissions to 1 tonne of product

For “simple goods”⁵⁶ the CBAM proposal outlines the calculation of the specific actual embedded emissions SEE_g (i.e. the embedded emissions per tonne of product) as follows:

$$"SEE_g = \frac{AttrEm_g}{AL_g}$$

Where SEE_g are the specific embedded emissions of goods g , in terms of CO₂e per tonne, $AttrEm_g$ are the attributed emissions of goods g , and AL_g is the activity level of the goods. The activity level is the amount of the goods produced in the reporting period in that installation.”

This approach is consistent with the considerations of this document. No modifications are proposed. Please note the remark added in section 3.5.2 regarding the treatment of installations which use several production routes simultaneously. In such cases, it is proposed to calculate the weighted (annual) average embedded emissions across all production routes of the same product applied at that site.

3.5.4 Step 4: Adding recursively precursor emissions

For the calculation of embedded emissions under the CBAM for “complex goods”⁵⁷ it is necessary the inclusion of precursors’ emissions as follows (Commission proposal):

$$"SEE_g = \frac{AttrEm_g + EE_{InpMat}}{AL_g}$$

Where $AttrEm_g$ are the attributed emissions of goods g , and AL_g the activity level of the goods, the latter being the amount of goods produced in the reporting period in that installation, and EE_{InpMat} are the embedded emissions of the input materials (precursors) consumed in the production process. Only input materials listed as relevant to the system boundaries of the production process as specified in the implementing act adopted pursuant to Article 7(6) are to be considered. The relevant EE_{InpMat} are calculated as follows:

$$EE_{InpMat} = \sum_{i=1}^n M_i \cdot SEE_i$$

Where M_i is the mass of input material i used in the production process, and SEE_i its specific embedded emissions for the input material. For SEE_i the operator of the installation shall use the value of emissions resulting from the installation where the input material was produced, provided that that installation’s data can be adequately measured.”

⁵⁶ Defined in the CBAM Regulation as “goods produced in a production process requiring exclusively input materials and fuels having zero embedded emissions”

⁵⁷ Defined in the CBAM Regulation as “goods other than simple goods”.

Here, several clarifications are relevant (to be considered for inclusion in the implementing act):

- In this version of the formulae, it is important that EE_{InpMat} and M_i refer to the total quantities of materials used over the whole reporting period, i.e. the normalisation to one tonne of the complex good are made in the same step by dividing by AL_g .
- Regarding the amount of materials used (M_i), it is necessary to take into account the total amounts added to the process⁵⁸, even if some material does not end up in the final product. For by-products, attribution rules for emissions will be necessary. Waste should be attributed zero embedded emissions. Where waste is internally recycled to replace virgin precursor material, this will not affect the calculation (i.e. there will be no double-counting of that amount), as still the total amount of material added to the process over the full reporting period is relevant for M_i .
- The Commission proposal states that the specific embedded emissions of the precursor shall be specific for the installation from where it is produced. This means that where the same material from different sources is used (e.g. coke purchased from different producers, as well as coke from own production), it will be necessary to consider the material from each source a separate material, so that its correct embedded emissions can be used.
- It is very relevant that the Commission proposal clarifies that only precursor materials listed as relevant in the implementing act have to be considered. This ensures that no infinitely complex value chains (and hence no full carbon footprints) need to be taken into account. Chapter 5 of this note makes an attempt to identify the relevant precursors). Criteria could be developed for what is considered relevant:
 - The production of the precursor must lead to significant GHG emissions which would be covered in the EU ETS, if it is produced in the EU; and
 - The amounts of precursor required for the production of the complex good are high enough that the precursor's embedded emissions contribute significantly to the embedded emissions of the complex good.
- Precursors are not necessarily simple goods themselves. Hence, SEE_i may have to be calculated from other precursors themselves (i.e. applying a recursive process). For example:
 - A mixed fertilizer may contain nitrogen in the form of nitrates, ammonium or urea. For calculating its embedded emissions, it is necessary to know the amounts of nitrates, ammonium salts and urea and their specific embedded emissions. For the production of ammonium salts, only the specific embedded emissions of ammonia are required. For nitrates, first the specific embedded emissions of ammonia and the emission from the production of nitric acid are required. From nitric acid, nitrates

⁵⁸ Note that the amounts M_i used in the process will usually differ from the amounts of precursor produced or purchased. Any relevant stock changes have to be taken into account here.

are produced. For urea, again the specific embedded emissions of ammonia are required, plus the emissions from the production of urea. Ammonia production may require knowledge of the embedded emissions of hydrogen, should it be produced in a non-integrated process (see also section 5.3.1).

Note: In chapter 5 production routes are discussed, where the embedded emissions of “scrap” are considered zero. **Strictly speaking, zero embedded emissions will only apply to “post-consumer” scrap**, i.e. materials for which the embedded emissions have been taken into account (i.e. covered by EU ETS allowances or CBAM certificates, as applicable) already at the stage the good has been brought to the market. This is in line with the definition of embedded emissions as discussed in section 2.2. Therefore, when in the processes discussed in chapter 5 a “scrap” is used, which has not been brought to the market and has later become scrap, i.e. when it is a scrap originating from the production process itself, it does not have zero embedded emissions, but the embedded emissions of the metal going into the process, which may be a mixture of virgin metal (e.g. pig iron or crude steel, or primary aluminium) and scrap (post-consumer scrap or process scrap).

3.5.5 Step 5: Taking into account the carbon price already paid

Theoretically, for completely fair treatment of materials produced in different installations in different jurisdictions, it would be necessary to calculate the (effective) carbon price already paid at the level of each precursor separately, before calculating the cumulative CBAM obligation for a tonne of final product imported into the EU. How this can be done was shown in presentations given by the Commission on the planned functioning of the CBAM, as well as in the EP amendment proposing a new Annex IIIa with an applicable formula. In our opinion a possible approach could take into account precursor materials as follows:

For each *good g*, the CBAM obligation COB_g is (expressed as number of CBAM certificates):

$$COB_g = (SEE_g - FA_g) \cdot M_g - CP_g$$

Where:

SEE_g ...Specific embedded emissions per tonne of good *g* (either the actual embedded emissions reported by the installation where it was produced, or the default value determined by the Commission).

FA_g ...Free allocation equivalent per tonne of good *g*. This would be equivalent to the EU ETS benchmark for the same product multiplied by a correction factor

for the percentage of free allocation granted for that product in the EU ETS during the phase-out period for free allocation⁵⁹. We assume that the same rule will apply to each product in value chains (i.e. for relevant precursor materials of complex goods). This means that the free allocation level does not have to be known to the user of the precursor material, as long as the effective carbon price already paid for each precursor is known (which in turn will depend on some other EU ETS benchmark and related free allocation level).

M_g ...Mass of good g imported in tonnes.

CP_g ...Correction for the carbon price already paid for the same quantity of good g in the jurisdiction where g was produced, if applicable and known. Since the formula above calculates COB_g as number of certificates, this carbon price must be converted into an appropriate number of CBAM certificates. Taking into account that the carbon price in the jurisdiction of the product's origin will be different, and that the carbon pricing might have a system of free allocation in place, CP_g might be calculated using a formula like the following:

$$CP_g = (E - FA) \cdot P_{origin} / P_{CBAM}$$

Where:

E ...emissions under the carbon pricing system;

FA ...free allocation or other discounts under the carbon pricing system;

P_{origin} ...Price of a tonne CO₂e in the country of origin of g , taking into account an appropriate exchange rate;

P_{CBAM} ...Price of one CBAM certificate (determined in accordance with Article 21 of the CBAM Regulation).

However, this is only proposed as a starting point for further discussion. The exact details for how to calculate the term CP_g are to be developed.

Note: Theoretically, CP_g can be negative according to the formula given. While the CBAM Regulation is quiet on this point, it can be assumed that the implementing act will clarify that in such cases CP_g will be considered zero. However, it would be preferable to have such a provision directly in the CBAM Regulation.

3.5.6 Step 6: Calculating the CBAM obligation

All the steps above applied to operators producing CBAM goods outside the EU. Their work ends when they have their information on embedded emissions per tonne of (simple or complex) product (and the carbon price already paid) verified and made available to the importer (the authorized declarant).

⁵⁹ This provision is found in the Commission's Fit for 55 proposal for the amendment of the EU ETS Directive. The final factors to be used for this project will depend on the phase-out timetable of the final EU ETS Directive.

Now, the importer has to calculate the CBAM obligation by summing up all quantities of imported goods falling under the CBAM, multiplied with the specific embedded emissions of each good (where goods from different sources are considered different goods due to different specific embedded emissions), taking into account a specific carbon price already paid outside the EU for each of these products.

Hence, the formula for calculating the total CBAM obligation could be as follows:

$$Obligation = \sum_{g=1}^n M_{g, imported} \cdot (SEE_g - cp_g)$$

Where $M_{g, imported}$ is the mass of good g imported (in tonnes), SEE_g the specific embedded emissions as calculated under steps 3 or 4, respectively, and cp_g the carbon price already paid based on step 5, but expressed as CBAM certificates per tonne of product (a method for calculating this still needs to be developed).

3.6 System boundaries

From what has been said about carbon footprints in section 2 and the need to make them comparable, it is essential that system boundaries are clearly defined – in the case of carbon footprints in product category rules, and for the purposes of the EU ETS and the CBAM in European legislation. Here we discuss what would be required for the sake of embedded emissions in the CBAM, and what elements can already be used from the EU ETS.

- **Installation boundaries:** This is a horizontal topic applying to all products in the CBAM. Rules to define installation boundaries should be similar to the EU ETS Directive and MRR. Some initial considerations are presented at the end of this section as well as in section 3.5.1.
- **Product definition:** Which products are covered by the CBAM is defined by using the CN codes that have been in use in customs already for decades. For the purpose of the CBAM, we just assume that this classification is sufficiently clear to identify which product is meant. However, the legislation to be developed will have to go a step further by defining specific product groups based on technological criteria, so that the system boundaries descriptions apply to them. E.g. the products of the iron & steel sectors may require to be grouped by production process (Blast furnace/BOF, scrap/EAF or DRI/EAF) and position in the value chain (pig iron / DRI – crude steel – hot rolled products)⁶⁰. This will lead to a list more disaggregated than in Annex I of the CBAM Regulation. Similar to the need to have a “one product, one benchmark” approach in the EU ETS, it will be “one

⁶⁰ Please note the remark added in section 3.5.2 regarding the treatment of installations which use several production routes simultaneously. In such cases, it is proposed to calculate the weighted (annual) average embedded emissions across all production routes of the same product applied at that site.

product and production route, one default value” in the CBAM⁶¹.

The legislation should provide a complete list of these distinguishable product groups and clear descriptions of the relevant system boundaries for each product, taking into account all elements listed here. In some cases it may also be necessary to define the **reference state** of the product to which the embedded emissions figures (and the default values) shall refer. For example, for aqueous solutions of ammonia, the embedded emissions should be based on the gaseous pure ammonia. (Also the FAR define the state of products or the point where the quantities are to be determined, e.g. “air dry” state for pulp and paper, “*Liquid iron saturated with carbon for further processing, considered as product of blast furnaces, and expressed in tonnes of liquid iron at the exit point of the blast furnace*” for hot metal (pig iron)).

- **Production process boundaries:** Similar to the sub-installations in the EU ETS, the CBAM implementing act should list the process boundaries applicable for each product. These can build on the information already available in the FAR Annex I, e.g. for nitric acid production: “*All processes directly or indirectly linked to the production of the benchmarked product as well as the N₂O destruction process are included except the production of ammonia.*” In the CBAM case, this description would be supplemented by the information “ammonia shall be treated as precursor material”, which would mean that ammonia’s embedded emissions have to be added to those of the nitric acid production process in order to arrive at the final embedded emissions of nitric acid.

If there are several production routes to arrive at the same product, the CBAM implementing legislation will have to **list boundaries for each production route separately**. As it is likely that innovative production routes will be developed, **generic rules** should be added for how an operator can define applicable system boundaries for production routes not yet given in the legislation. Sometimes the production route may be unknown to the authorised declarant. Therefore, it will be necessary to define a “**default production route**” for each product.

- **List of relevant precursors:** It will be an essential element to list all precursors to be taken into account for each production route of each good included in the CBAM. Notably, there will be a need to have a default consumption level per tonne of good produced with this precursor (M_i in the formulae in section 3.5.4) for each precursor in each production route. If indirect emissions (i.e. emissions from electricity use) are included in the CBAM obligation, the implementing act should state whether or not electricity is relevant or not, just like it will identify which precursor materials are relevant. This would simplify the system and reduce administrative burden, since indirect emissions are relatively small in some production processes, so that they could be considered irrelevant, as is the case for some other precursors discussed in this note. Rules will also be required how to treat recycled materials (waste) as input,

⁶¹ The expression “one default value” is without prejudice to possible geographic differentiation.

i.e. substituting virgin precursor materials. The simplest approach would be to assign zero embedded emissions to recycled materials, as their embedded emissions were already accounted for at the stage they were first brought to the market. However, the fact that a material is recycled waste would require verification for allowing such zero embedded emissions.

Remarks on installation boundaries

In the EU ETS Directive, an installation is defined as *“a stationary technical unit where one or more activities listed in Annex I are carried out and any other directly associated activities which have a technical connection with the activities carried out on that site and which could have an effect on emissions and pollution;”* and an operator as *“any person who operates or controls an installation or, where this is provided for in national legislation, to whom decisive economic power over the technical functioning of the installation has been delegated”*. In this document, these terms are used in the same way as in the EU ETS, even if installations and operators outside the EU are meant. However, which “activities” are meant is only clear if the activities of Annex I of the EU ETS Directive are explicitly listed. However, this may be circumvented by listing the relevant production process and their elements to be covered by the CBAM.

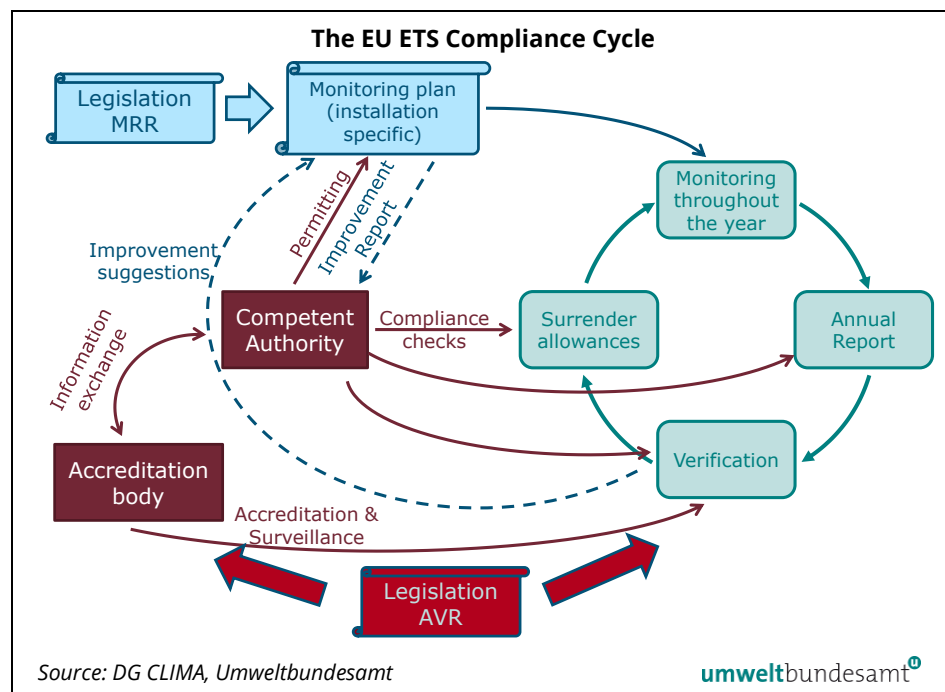
Furthermore, the MRR requires that all emissions related to EU ETS activities are included. Although there are simplified monitoring approaches allowed for source streams or emission sources with relate to very small emissions, it is not allowed to omit any emissions (e.g. below a certain cut-off threshold). For ensuring consistency, it is proposed that the same principle should apply in the CBAM. However, there is a possibility to limit complexity at the stage of precursor materials, where the legislation has the possibility to define only the major contributors to embedded emissions as relevant. By stating these in the legislation, it will be avoided that operators can make arbitrary choices.

For installations that produce not only goods falling under the CBAM, but also other ones, there may, however, remain some room for flexibility. MRV rules might allow the operator to monitor only such source streams and emission sources which are connected to the production of CBAM goods and their precursors, provided that they can be clearly distinguished and metered. Rules would then have to clarify that in the case of central heat and electricity supply, these would have to be monitored in their completeness, and that still the attribution of emissions to individual goods will have to aim at 100% coverage. Transparency of the assumptions and their rationale would have to be provided to the verifier (and the authority who checks the CBAM declarations). The minimum requirement might be e.g. to list all source streams *not* relevant for monitoring.

3.7 Compliance cycle and certification system

3.7.1 The EU ETS compliance cycle

Figure 2: The EU ETS compliance cycle (based on MRR Guidance document No.1)



[Text taken from MRR GD1 shortened and with modifications]

The annual process of monitoring, reporting, verification of emissions, surrender of allowances, and the competent authority's procedure for accepting emission reports are often referred to as the "compliance cycle". Figure 2 shows the main elements of this cycle.

On the right side of the picture there is the "main cycle": The operator monitors the emissions throughout the year. After the end of the calendar year (within three months⁶²) he must prepare the Annual Emissions Report (AER), seek verification and submit the verified report to the competent authority (CA). The verified emissions must correlate with the surrender of allowances in the Registry system. Thereafter the monitoring goes on, as shown in the picture. More precisely, the monitoring continues without any stop at the end of the year.

The monitoring process needs a firm basis. Resulting data must be sufficiently robust for creating trust in the reliability of the EU ETS, including the fairness of the surrender obligation, and it must be consistent throughout the years. Therefore, the operator must ensure that the monitoring methodology is documented in writing, and cannot be changed arbitrarily. In the case of the EU ETS, this written methodology is called the Monitoring Plan (MP) of the installation

⁶² According to national legislation, this period may be shorter.

(see Figure 2). It is part of the permit, which every installation in the EU ETS must have for the emission of greenhouse gases.

The figure also shows that the monitoring plan, although very specific for an individual installation, must follow the requirements of the EU-wide applicable legislation, in particular the Monitoring and Reporting Regulation. As a result, the MRV system of the EU ETS is able to square the circle between strict EU-wide rules providing reliability and preventing arbitrary and undue simplifications, and allowing for sufficient flexibility for the circumstances of individual installations.

Figure 2 also shows some key responsibilities of the competent authority. It has to supervise the compliance of the operators. As the first step, the CA has to approve every monitoring plan before it is applied. This means that the monitoring plans developed by the operator are checked for compliance with the MRR's requirements. Where the operator makes use of some simplified approaches allowed by the MRR, this must be justified by the operator, for example, based on the grounds of technical feasibility or unreasonable costs, where otherwise required higher tiers cannot be achieved.

Secondly, the CA may carry out inspections at installations, to gather assurance that the monitoring plan is well aligned to the reality of the installation. The CA may, for example, check if the installed meters are of the type laid down in the monitoring plan, whether required data is retained, and written procedures are followed as required.

Finally, it is the responsibility of the competent authority to check the annual emission reports. This includes spot checks on the already verified reports, but also cross-checks with figures entered in the verified emissions table of the registry system, and checking that sufficient allowances have been surrendered.

Moreover, the compliance cycle has a wider perspective. As Figure 2 shows, there is a second cycle. This is the regular review of the monitoring plan, for which the verification report may provide valuable input. Besides, the operator is required to continuously strive for further improving the monitoring methodology. Any inspections by the CA should also *inter alia* aim at identifying elements of the monitoring methodology which are not appropriate any more, for example, after technical changes have been made to the installation.

On the bottom of Figure 2, the governance system for verification is included: A national Accreditation Body (NAB) is responsible for accreditation of the verifiers. Without accreditation (or if accreditation is suspended due to irregularities found in the verifier's work), the verifier is not allowed to carry out verification. The accreditation includes regular (e.g. annual) surveillance activities. The legal basis and detailed requirements for verification and accreditation are laid down in the AVR. It also requires a regular information exchange between the CAs and NABs, in particular where verifiers accredited in other Member States are involved.

What can be learned for the CBAM from the EU ETS compliance cycle is in the first place the important role of a monitoring plan. However, monitoring

plans may be considered an administrative burden at the time of introducing the CBAM. Although they are considered best practice, they could be kept as voluntary elements at least for some transition phase, or additional incentives for operators should be considered to develop their monitoring plans. As there are no competent authorities in the case of CBAM, verifiers could take over the responsibility to validate monitoring plans. This has for example been the case in the MRV Regulation⁶³ for maritime transport. The latter will form the basis for MRV for maritime transport activities also when they will be included in the EU ETS in line with the “Fit for 55” package. As an alternative, the responsibility for validating monitoring plans could be performed by applying a certification scheme as described in section 3.7.2.

Secondly, the defined reporting period of one year seems also appropriate for the CBAM, so that authorised declarants can use the same embedded emission values for such a period, and may align reporting obligations with carbon pricing systems in other jurisdictions. Thirdly, the system of accreditation as tool for supervising verifiers is important and an internationally accepted and understood concept. It has already been included in the Commission proposal.

Finally, the concept of continuous improvement is worth further consideration: For the CBAM, it may not be appropriate to require regular “improvement reports” as under the MRR. However, for making the CBAM cost-effective but robust, and for giving operators time to adapt to its requirements, the implementing act under the CBAM Regulation should provide some clause that allows the operator to start with some “best available data sources” (see also section 3.3), and later on improve the monitoring system.

Timing of the CBAM compliance cycle

In the EU ETS, the reporting period is the calendar year, and emission reports are due by 31 March⁶⁴ of the subsequent year. It has been found that annual reporting on emissions data offers a good balance between timeliness of data and administrative burden⁶⁵. The interval of three months between the end of the reporting period and the submission of verified reports has also been widely found reasonable⁶⁶, with some Member States allowing only two months

⁶³ Regulation (EU) 2015/757 of the European Parliament and of the Council of 29 April 2015 on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport, and amending Directive 2009/16/EC.

⁶⁴ The MRR allows Member States to prescribe an earlier submission date, but not earlier than 28 February.

⁶⁵ The impact assessment for the 2008 review of the EU ETS found that the annual reporting is appropriate, and more frequent reporting would lead to undue administrative burden. See SEC(2008) 52, https://ec.europa.eu/clima/document/download/1ca410f6-5586-4d67-8c96-1a3acb767df1_en?filename=sec_2008_52_en.pdf

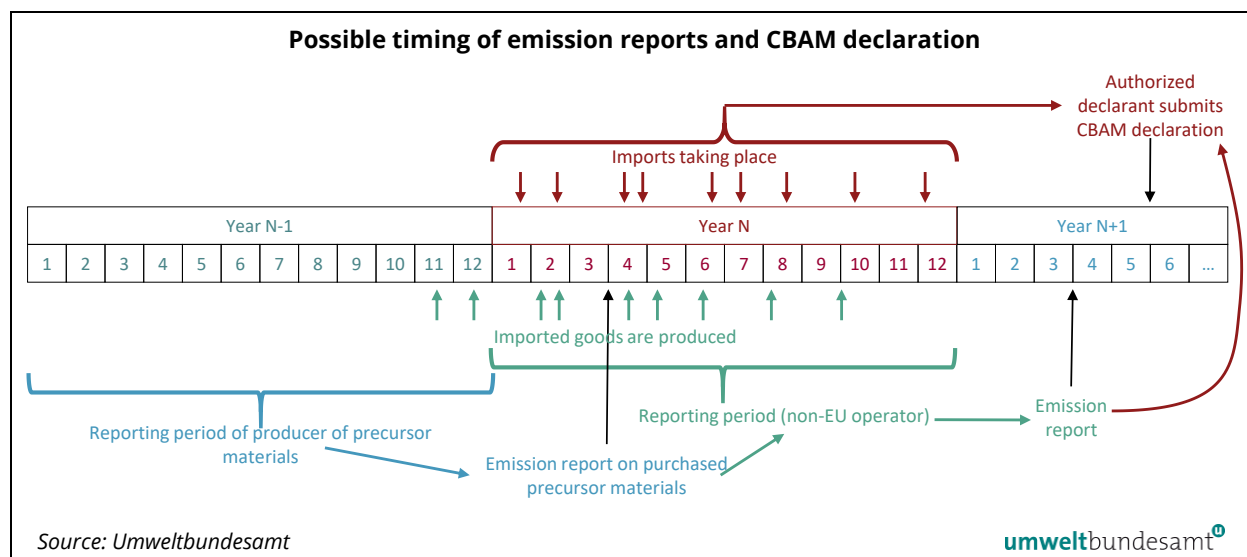
⁶⁶ In this context it is important to mention that verification is a bottleneck. The system only works because verifiers schedule part of the verification tasks throughout the reporting year, and require only a limited amount of time to finalise verification conclusions after the end of the reporting period.

for that purpose. Consequently, we assume here that it is reasonable to require the same timing for operators outside the EU who intend to provide actual data on embedded emissions of goods to the authorised declarants. Using the same reporting cycle for all producers inside and outside the EU would furthermore have the advantage that only one set of rules needs to be followed by all operators, which will allow also equal treatment of exported EU products which may serve as precursors for goods that fall under the CBAM. However, as an exception to the rule, it might be useful to allow reporting periods other than calendar years to installations which are subject to another legally mandatory MRV system, e.g. if they are subject to a national ETS outside the EU. Provided the level of oversight by a competent authority or at least accredited verifier is given, such deviation would provide a reduction of administrative burden and would at the same time reduce the risk of reporting errors.

In accordance with Article 6(1) of the Commission's proposal, the annual CBAM declaration by authorised declarants is due by 31 May each year for the previous calendar year. The proposed timing for reporting of embedded emissions would allow the declarants up to two months for using these data to compile the CBAM declaration, which seems well feasible, provided that efficient communication between producers of goods and authorised declarants can be established. A central database [operated by the Commission] would be ideal to support such efficient communication, if operators report the embedded emissions to that database, and declarants can gather data for the CBAM declaration from the database. This would also increase data quality and allow a high level of automatisisation on the side of authorities in checking the CBAM declarations.

As can be seen from Figure 3, the proposed timing will lead to a reasonable coincidence of emissions data with the actual time of production, although there may be some delay between production and import. However, a longer delay is inherent in this approach for data on embedded emissions of precursor materials. These may be one year older than the rest of the data, if the precursors are not produced in the same installation. However, over a period of several years, deviations between actual and reported data caused by delayed reporting would equal out. Therefore the proposed approach seems reasonable, and has the advantage of an elegant simplicity.

Figure 3: Impact of a one-year reporting period on the timeliness of CBAM declarations. Note that this shows only the case of calendar years as reporting periods, while it might be possible to accept other one-year periods under certain conditions, such as for the purpose of aligning with another mandatory MRV system's timeline.



3.7.2 Certification systems under RED II

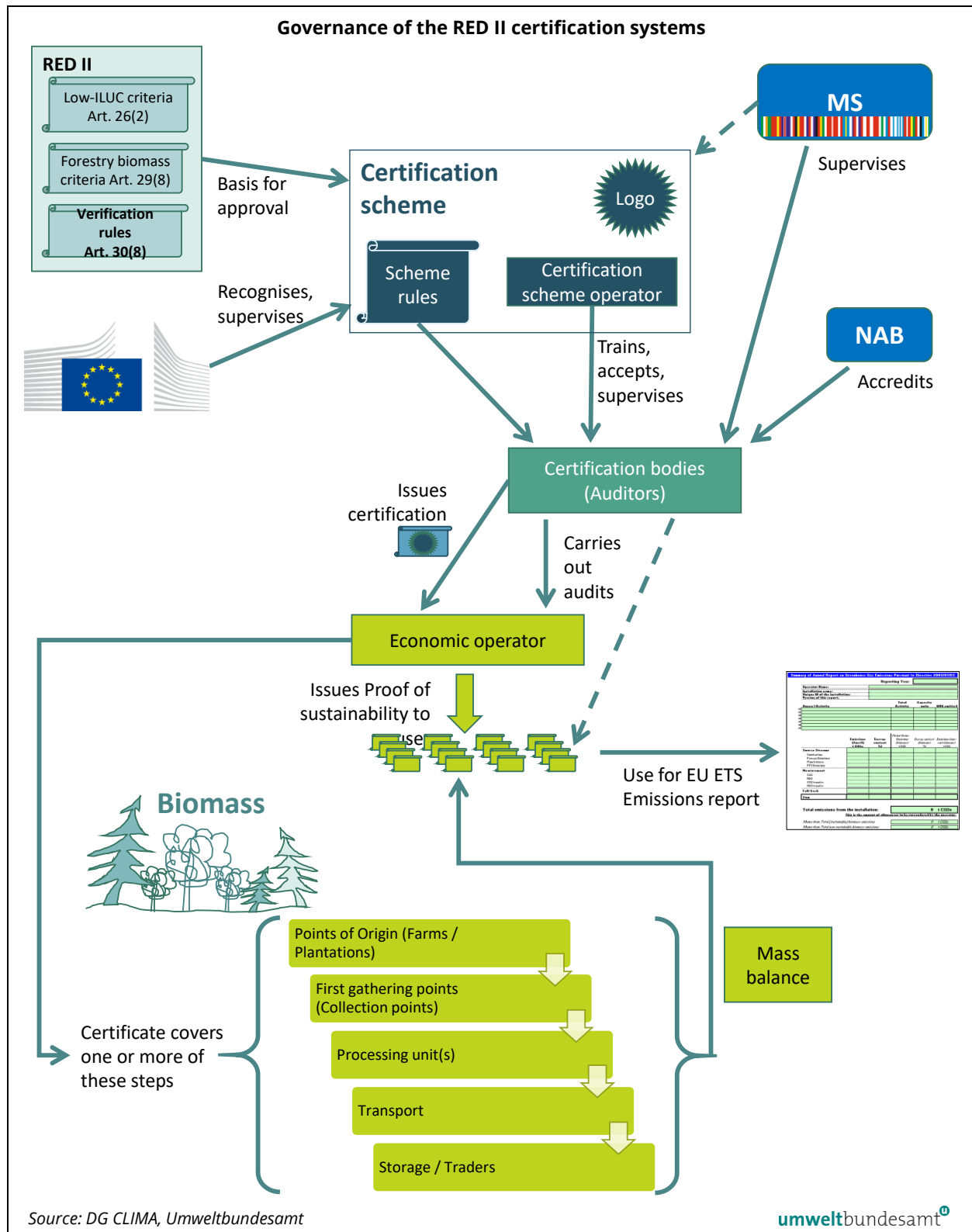
The Renewable Energy Directive requires that biomass, when used for generation of electricity, heating or cooling, in order to be eligible for financial support and for counting towards the Member State's renewable target, complies with certain sustainability and GHG savings criteria. Providing the relevant evidence is not simple and requires special expertise and a controlled data gathering framework. As biomass must fulfil those criteria without prejudice to the country of origin, internationally working certification schemes are required.

Below we give a short overview of how these systems work. *[Figure 4 and the text below are taken from MRR GD3 (unpublished draft, written by Umweltbundesamt for DG CLIMA) with minor modifications.]*

Figure 4 provides an overview of the governance structure of certification schemes including the recognition by the Commission. First, certification scheme operators set up their certification scheme's rules (e.g. which scope they cover, which competence criteria they apply for their certification bodies and their auditors, which templates economic operators have to use, etc.). These rules have to be published by the certification scheme and must comply with the Implementing Regulation⁶⁷ pursuant to Article 30(8) of the RED II. That Regulation is also the basis against which the Commission checks the scheme before recognising it.

⁶⁷ Commission Implementing Regulation (EU) 2022/996 of 14 June 2022 on rules to verify sustainability and greenhouse gas emissions saving criteria and low indirect land-use change-risk criteria, available from http://data.europa.eu/eli/reg_impl/2022/996/oj

Figure 4: Schematic description of how RED II certification schemes work (taken from draft MRR guidance document No 3, written by Umweltbundesamt for DG CLIMA⁶⁸)



⁶⁸ https://climate.ec.europa.eu/system/files/2022-10/gd3_biomass_issues_en.pdf

Once a certification scheme is recognised by the Commission, the certificates issued to economic operators and proofs of sustainability issued by those economic operators under the certification scheme have to be accepted in all Member States, as well as by all other recognised schemes (e.g. for parts of value chains). Recognition by the Commission is valid for a maximum of five years.

The term “economic operator”⁶⁹ used in the context of the RED II covers several different cases, and the scope of their certification can vary accordingly. For the purpose of EU ETS, an operator of an installation using biomass can be the “economic operator”. As shown in Figure 4, the biomass value chain can be complex, starting from the farm or forest (point of origin) over a “first gathering point”⁷⁰ (e.g. a trader’s warehouse or a train loading station), various transport and storage stages, and the processing into biofuels. All these steps must be covered by the mass balance system under Article 30(1) of RED II for ensuring that there are neither data gaps nor double counting of biomass quantities. Biomass certification schemes usually offer different scopes of certification, so that economic operators can get certificates specifically for the steps of the value chain which the operators cover. If e.g. an economic operator only carries out the “first gathering point” activity, or only production of biofuels from certain raw materials, the certificate will be issued only for these operations.

Furthermore, some certification schemes do not cover all the elements of the RED II. For example, it is not a given that all certification schemes also cover assessing the mass balances, some do not cover forest materials. Also the specific certification as “low-ILUC”⁷¹ biomass is not always offered by certification schemes.

In this system, *certificate*⁷² is what certifies that an economic operator complies with the rules of the certification scheme. A *Proof of Sustainability*⁷³ is issued by

⁶⁹ Defined by Article 2(11) of the implementing act: “‘economic operator’ means a producer of raw material, a collector of waste and residues, an operator of installations processing raw material into final fuels or intermediate products, an operator of installations producing energy (electricity, heating or cooling) or any other operator, including of storage facilities or traders that are in physical possession of raw material or fuels, provided that they process information on the sustainability and greenhouse gas emissions saving characteristics of those raw materials or fuels;”

⁷⁰ Defined by Article 2(12) of the implementing act: “‘first gathering point’ means a storage or processing facility managed directly by an economic operator or other counterpart under contractual agreement that is sourcing raw material directly from producers of agricultural biomass, forest biomass, wastes and residues [...]”.

⁷¹ ILUC = Indirect land-use change; Art. 2(37) RED II.

⁷² Article 2(4) of the implementing act defines “‘certificate’ means a conformity statement by a certification body within the framework of a voluntary scheme, certifying that an economic operator complies with the requirements of Directive (EU) 2018/2001 [the RED II]”;

⁷³ Article 2(23) of the implementing act defines “‘proof of sustainability’ means a declaration by an economic operator, made on the basis of a certificate issued by a certification body within the framework of a voluntary scheme certifying the compliance of a specific quantity of feedstock or fuels with the sustainability and greenhouse gas emissions savings criteria set out in Articles 25(2) and 29 of Directive (EU) 2018/2001 [the RED II]”.

the economic operator for confirming that a certain consignment of biomass material⁷⁴ fulfils the sustainability or GHG savings criteria. The role of a certification body is therefore different from the EU ETS verifier in that not specific environmental data are verified, but the certification means that *the economic operator is certified as being capable* of managing the sustainability information, GHG savings data or the relevant mass balance system, depending on the certification scope. Depending on the certification scheme's rules, such certificate is valid for one year from the certification⁷⁵ (i.e. forward-looking, while EU ETS verification confirms data from the past). This does not mean that the auditor will not check data from specific consignments (batches) of biomass, but still the certificate proves that the economic operator is capable of issuing "proofs of sustainability" for the biomass material.

An important part of the certification scheme's rules is the framework for auditing⁷⁶. The implementing act pursuant to Article 30(8) requires:

- The certification body acting on behalf of the certification scheme shall be accredited to ISO 17065 ("Conformity assessment – Requirements for bodies certifying products, processes and services").
- Audits of economic operators are to be carried out using ISO 19011 ("Guidelines for auditing management systems").
- If the certification scheme performs audits on actual GHG values, it shall be accredited to ISO 14065 ("General principles and requirements for bodies validating and verifying environmental information").
- Voluntary schemes shall set up training courses for their auditors covering the schemes' specific rules, and shall carry out supervision on them.

The key learning from that system for the CBAM is that the Commission laid down requirements for such systems in an implementing act, and performs "recognition" of the schemes based on this implementing act. Recognition can be withdrawn if irregularities in the scheme's operations are found, and must be renewed every five years, which gives the Commission significant enforcement capabilities.

The main difference between RED II and CBAM would be, however, that the certification body / verifier would have to perform a "normal" verification (like under the EU ETS) on *data gathered in the past* (in the previous year), not on the *capability* of the operator to monitor appropriately⁷⁷.

⁷⁴ The precise wording of the RED II would be "biofuel, bioliquid or biomass fuel", where "biomass fuel" means biogas and solid biomass used as fuels.

⁷⁵ The certificate has to give the validity period.

⁷⁶ In order to clarify the difference from EU ETS verification, this document uses here the term "certification body" for the (accredited) legal person / company, and "auditor" for the person doing the audits.

⁷⁷ However, should the CBAM rules for MRV require the operators to have a monitoring plan, such "forward looking" validation of the MP would become element of the system.

Like verifiers according to the CBAM proposal, certification bodies under RED II have to be accredited by the NAB of a Member State, which provides a means of control over them from the EU side, even if they are operating overseas. The use of international standards is helpful in this regard.

An important element is also the transparency rules: Each certification system must publish the rules it applies, the list of certification bodies accepted, and the list of certificates issued (which allows checking whether a certificate shown by an economic operator is still valid). In CBAM terms, certification systems could publish a list of actual specific embedded emission values from installations they have verified, although a central database at EU level for this purpose would be even better. Article 10(7) could be strengthened such that embedded emissions (and underlying emission reports / verification reports) should be kept in the database.

The most important point, however, is the multiplier potential of this concept. The Commission sets the rules, several certification systems are set up (by the private sector), each certification system can train and employ many auditors. Market demand would lead to the required number of auditors per country, and language barriers would likely be less problematic. The certification scheme operators would furthermore be responsible to disseminate knowledge on relevant rules (legislation, guidance documents and reporting templates) of the CBAM.

Possible requirements in the CBAM regulation

If the decision were made that a governance structure such as the certification schemes of RED II would be useful for the CBAM, the CBAM Regulation would need some clauses that verification may be put into the hand of certification schemes, provided they are recognised by the Commission. Articles 30(4), (5), (7) and (8) of RED II can be used as inspiration. There would be the need for an implementing act like the one⁶⁷ under Article 30(8) of RED II defining requirements on certification schemes.

4 EXISTING MRV RULES

This chapter is dedicated to a short review of existing MRV rules which might help the final definition of MRV rules for determining the embedded emissions of goods under the CBAM.

It is worth to emphasise that the EU ETS MRV system, on which this document primarily builds, is nothing exotic or esoteric. From the very beginning of the EU ETS, the EU ETS MRV system was aligned with IPCC GHG inventory rules, and building on industry experience at that time (in particular the GHG protocol, which itself was developed with strong industry participation). Industry stakeholders have been frequently consulted before finalisation of the MRV system in its current form (i.e. as laid down in the legal acts listed in section 3.1). The international standards such as ISO 14064-3 and ISO 14065 again took experience and requirements of the EU ETS MRV into account, when they were developed. Also other emission trading systems which have been or are currently developed in many jurisdictions⁷⁸ were strongly influenced by the EU ETS experience, such as the Californian ETS, the Korean and Chinese national ETS, etc. International platforms for information exchange such as ICAP⁷⁹ and PMR⁸⁰ have supported the information exchange by providing workshops, trainings and publications which have also led to a certain degree of soft harmonisation between carbon pricing systems and their MRV systems.

Therefore, the basic assumption for the CBAM's MRV system is that even though specific rules will have to be put in place for the CBAM, which will strongly build on the EU ETS, operators in many countries will neither have to start from scratch, nor will they find it extremely difficult to adjust to the CBAM's rules. However, for countries where no carbon pricing is in place yet, the CBAM may be a big challenge. The aim of this chapter is to explore whether this assumption is valid.

4.1 MRV rules in the EU ETS

Throughout this document many references have already been made to the EU ETS legislation and the extensive guidance material available. Here we will only summarize what rules are available and which gaps need to be filled for the CBAM's MRV system.

⁷⁸ An overview of emission trading systems can be found e.g. under <https://icapcarbonaction.com/en/ets-map>

⁷⁹ International Carbon action Partnership, <https://icapcarbonaction.com>

⁸⁰ The World Bank's Partnership for Market Readiness, <https://www.thepmr.org/>

4.1.1 Available rules

The MRR contains rules for the following details on monitoring of emissions *at installation level*:

- Definitions and principles (see section 3.3);
- A building block system of several monitoring methodologies (see sections 3.4.1 to 3.4.6) and calculation formulae (same section, and 3.5.1);
- Allowed simplifications for small/simple installations and small source streams and emission sources;
- Rules for the determination of fuel and material quantities (“activity data”), including situations where the metering equipment is not owned by or under control of the operator, but e.g. the fuel supplier;
- Approaches using either default values or laboratory analyses for the determination of “calculation factors” (NCV, emission factors, carbon content, biomass fraction, oxidation factor, conversion factor, see also section 3.4.1);
- Requirements for minimum uncertainties to be met for measurements;
- Requirements for sampling⁸¹ for the purpose of laboratory analyses, and requirements for the laboratory⁸²;
- Rules for how to apply CEMS (see also section 3.4.2), in particular requirements for maintenance and calibration, by reference to European or international standards;
- Rules for biomass (including conditions for zero rating based on the criteria of the RED II);
- Rules for monitoring of N₂O and PFCs (see sections 3.4.4 and 3.4.5) and for CCS (3.4.6). Notably CCU rules are still pending until the current proposal for an update of the EU ETS Directive is adopted;
- Rules for quality management and the internal control system (including risk assessment);
- Requirements for regular improvement reports and monitoring plan updates;
- Requirements for electronic templates or IT systems for transmitting data to the competent authority;
- Minimum content of the monitoring plan and annual emission report, and requirements for retaining data for 10 years (and what data to keep);
- Activity (sector) specific rules on monitoring, e.g. boundaries of the activity, which monitoring methods to use, deviations from the standard tier system, etc.
- Default emission factors (mostly based on IPCC GL 2006) and GWP values to be applied;

⁸¹ Where applicable, installations must have a sampling plan which ensures representative sampling, and safeguarding a minimum number of samples per year.

⁸² Laboratories must be accredited to ISO 17025, or meet equivalent quality criteria.

- Rules how the competent authority can determine the emissions in the absence of the operator's report, or in case of negative verification.

The free allocation rules contain MRV rules for the following areas relevant for the CBAM:

- An obligation to monitor *sub-installation level* data in addition to the monitoring obligations of the MRR;
- Obligation for having an approved "monitoring methodology plan" as supplement to the monitoring plan already in place under the MRR;
- A hierarchy of what "best available data sources" are in the absence of a tier system like under the MRR;
- Rules on metering of heat (See section 3.4.7) and electricity (3.4.8);
- Rules for attribution of emissions to products (sub-installations) (see section 3.5.2.1);
- Rules for sub-installations for processes outside the product benchmark definitions ("fall-back sub-installations");
- Detailed product definitions related to benchmarks, and related system boundaries;
- List of parameters to be monitored and reported;
- Minimum content of the monitoring methodology plan;

The AVR covers the following topics:

- Verification rules for data sets under both, MRR and FAR;
- Definitions and principles of verification;
- Requirements for the different steps of verification (pre-contract stage, strategic analysis, risk analysis, verification plan, data verification, independent review, etc. – this part is highly compatible with ISO 14064-3)
- Site visits and criteria under which conditions the site visit may be waived; Virtual site visits (e.g. under Pandemic situations);
- Rules for accreditation and surveillance of verifiers (highly compatible with ISO 14065);
- Competence requirements for auditors and lead auditors;
- Requirements for the accreditation body;
- Rules on information exchange between NAB and CA;
- A list of accreditation scopes for verifiers, in order to match the scope of accreditation to certain sectors for which the verifier has proven competence.

All of the above elements can most likely be used as starting point for developing the CBAM MRV rules, although some simplifications should be made in order to keep the resulting legislative act manageable, and for making it applicable to operators who may lack resources for implementing them perfectly right from the start.

4.1.2 Gaps (areas without MRV rules in the EU ETS)

Comparing the list of MRV rules already existing for the EU ETS (section 4.1.1) against the needs of the CBAM (based on the calculation rules in section 3.5), we identify the following gaps for which new MRV rules need to be developed or taken from other carbon pricing systems or international standards:

- If the review of other MRV systems (sections 4.2 and 4.3) finds useful monitoring provisions not yet available in the EU ETS (e.g. conditions for the use of PEMS), there would be a possibility to add similar provisions to the CBAM implementing act in order to make it more flexible for users outside the EU;
- Rules for determining embedded emissions of precursor materials if they are sourced from other installations (known or unknown sources);
- Rules for determining the effective carbon price already paid (for the installation's own products as well as for purchased precursor materials, including those of unknown origin;
- Rules for waste gas export and use, if applicable, and if decided to be different than under the FAR;
- Specific product definitions not yet available, e.g. Direct Reduced Iron (DRI), urea, mixed fertilizers, etc.;
- System boundary definitions if not yet available in the FAR, e.g. for hot-rolling of steel, which is currently under fall-back approaches;
- Definitions of the production routes and their precursor materials to be taken into account;
- If necessary, rules for allowing or requiring the use of default values;
- If found desirable, requirements on certification schemes (based on approaches known from the RED II, see section 3.7.2);
- Article 7(6) furthermore requires to include rules for how default values shall be defined.

4.2 Relevant (international) standards

The following international standards contain elements which could be of relevance to the CBAM:

- **Horizontal standards** on GHG emissions and verification:
 - **ISO 14064-1:2018** – Greenhouse gases – Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.

This standard defines general principles for monitoring and reporting of GHG emissions at company level, which can be easily broken down to installation level like in the EU ETS. The standard is building on IPCC guidelines, which also form a basis for the EU ETS rules. As has already

been discussed in section 2.2, the standard is not restricted to direct emissions. It outlines only a general framework for GHG inventories (i.e. MRV approaches) and leaves high flexibility for approaches which are compatible with this standard. The EU ETS MRV rules are largely compatible with ISO 14064-1, but are more specific. Therefore, the ISO standard will most likely not feed directly into the CBAM's MRV rules, but may be helpful in providing guidance to operators in third countries who may be familiar with its requirements.

- **ISO 14064-2:2019** – Greenhouse gases – Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements.

This standard sets out a general framework for projects for emission reduction. Therefore there is no direct applicability in the CBAM. However, this framework is respected by most systems for voluntary carbon reductions as well as the UN-regulated JI and CDM projects. When looking for MRV experience in third countries on which CBAM can build, such project activities will be important. Nevertheless, ISO 14064-2 itself will not be further considered for this project.

- **ISO 14064-3:2019** – Greenhouse gases – Part 3: Specification with guidance for the verification and validation of greenhouse gas statements.

This standard is the basis for GHG verifiers around the world. It also formed the basis for the development of the EU ETS Regulation on verification (the AVR). Again, the standard itself is system-neutral, i.e. without further detailed rules it cannot be easily applied. In the EU ETS, the detailed requirements are laid down in MRR and AVR, for the purpose of the CBAM the relevant implementing acts will fill this gap. The latter will have to be developed by respecting ISO 14064-3 in order to ensure international understanding of the requirements, and for ensuring an equal level of verification in the CBAM as in the EU ETS.

- **ISO 14065:2020** – General principles and requirements for bodies validating and verifying environmental information.

Again, this is a universally known and applied standard. It is the foundation of all accreditations of GHG verifiers. It was used for developing the AVR. Therefore, if the CBAM Regulation requires verifiers to be accredited on basis of the AVR, verifiers will automatically comply with this standard, which will be helpful for international acceptance of these verifiers.

- **ISO 14067:2018** – Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification.

As discussed in section 2.3, the international standard for carbon footprint of products is largely compliant with the needs of the CBAM, provided more detailed rules – the “product category rules” are laid down in the legislation of the CBAM. Therefore it is expected that actors in the CBAM who are familiar with this standard will find the CBAM rules easy to understand. However, it will require some effort in the CBAM guidance documents to highlight some differences in vocabulary (the stand-

ard uses e.g. “allocation” of emissions to different products, while readers familiar with the EU ETS or CBAM would use the word “attributed emissions”, etc.). It will also be important to highlight the exact system boundaries of embedded emissions. For CBAM actors not familiar with carbon footprints, however, it will be more useful to concentrate on the CBAM rules themselves, without making the detour of first trying to get acquainted with carbon footprints.

- **Sector-specific standards** on GHG emissions (for assessment, here the European (EN) standards were used, as some of the corresponding ISO standards⁸³ are still at the drafting stage):
 - **EN 19694-1**:2016 and ISO 19694-1:2021 – Stationary source emissions – Determination of greenhouse gas emissions in energy-intensive industries – Part 1: **General aspects**.
 - **EN 19694-2**:2016: – Stationary source emissions – Determination of greenhouse gas emissions in energy-intensive industries – Part 2: **Iron and steel** industry
 - **EN 19694-3**:2016 and ISO/FDIS 19694-3 – Stationary source emissions – Determination of greenhouse gas emissions in energy-intensive industries – Part 3: **Cement** industry
 - **EN 19694-4**:2016 and ISO/FDIS 19694-4 – Stationary source emissions – Determination of greenhouse gas emissions in energy-intensive industries – Part 4: **Aluminium** industry
 - **EN 19694-5**:2016 and ISO/FDIS 19694-5 – Stationary source emissions – Determination of greenhouse gas emissions in energy-intensive industries – Part 5: **Lime** industry
 - **EN 19694-6**:2016 and ISO/FDIS 19694-6 – Stationary source emissions – Determination of greenhouse gas emissions in energy-intensive industries – Part 6: **Ferroalloys and silicon** industry

This series of European standards copies basically the requirements of the EU ETS Regulation on monitoring and reporting (the MRR 2012⁸⁴) into standards and adds further sector-specific aspects (e.g. system boundaries) and detailed examples for emission calculation. It adds for example information not available in the MRR, such as uncertainty values for typical measurement instruments commonly used in these sectors.

These standards furthermore exceed the needs of the EU ETS, since also indirect emissions and to some extent “upstream”⁸⁵ energy consumption

⁸³ From the identical numbering and the publicly available parts of the ISO standards, it is assumed that the ISO standards will be (near to) identical to the EN standards.

⁸⁴ Commission Regulation (EU) 601/2012 – note that this version of the MRR applied during the third phase of the EU ETS. For use from 2021 onwards, it was replaced by Commission Implementing Regulation (EU) 2018/2066 (the MRR 2018), which is meant whenever the MRR is mentioned in this discussion note. However, the differences between both versions of the MRR are minimal when CBAM requirements are concerned.

⁸⁵ I.e. energy or emissions associated with the production of a source stream used in the process under consideration.

or emissions are included in some cases. These standards also allow performance monitoring by using key performance indicators, and identification of emission reduction potentials, which may be helpful to companies, but not covered in EU ETS legislation.

It is unknown to which extent these standards are used in practice. When it comes to the EU ETS, the sole requirement is compliance with the EU Regulations. The use of the standards is not required by legislation. Therefore, they would more or less fulfilling the role of additional guidance documents.

- Additional standards for the **iron and steel sector**:
 - **ISO 14404-1:2013** – Calculation method of carbon dioxide emission intensity from iron and steel production – Part 1: **Steel plant with blast furnace**
 - **ISO 14404-2:2013** – Calculation method of carbon dioxide emission intensity from iron and steel production – Part 2: Steel plant with **electric arc furnace (EAF)**
 - **ISO 14404-3:2017** – Calculation method of carbon dioxide emission intensity from iron and steel production – Part 3: Steel plant with electric arc furnace (EAF) and coal-based or gas-based **direct reduction iron (DRI)** facility
 - **ISO 14404-4:2020** – Calculation method of carbon dioxide emission intensity from iron and steel production – Part 4: **Guidance** for using the ISO 14404 series

This series of standards builds on the Worldsteel climate action data collection handbook⁸⁶. It is different from the EN standards described above in that it does not contain requirements on the “how” of monitoring, but only on the “what to report”. It provides a consistent methodology for comparing the performance of different steel production sites by overcoming the difficulties that some plants produce some precursor materials themselves, while others purchase them (this includes heat and electricity). For that purpose, a system of including upstream emissions (comparable to the concept of precursors’ embedded emissions for the CBAM) and “credit emissions” (for attributing some emissions to the downstream process such as e.g. a power plant using the blast furnace gas).

It is unclear if this standard would be helpful in the context of the CBAM. However, the descriptions of system boundaries may be helpful. Furthermore the large number of default values for all kinds of materials used in the sector (including values for “upstream emissions”) may be useful in corroborating the results of the project developing default values for the CBAM.

⁸⁶ The ISO series cites version 6 of the handbook. The one currently available from Worldsteel’s website is version 10: <https://worldsteel.org/steel-topics/environment-and-climate-change/climate-action/climate-action-data-collection/>

4.3 Applicability of MRV rules of other carbon pricing systems

For the purpose of the CBAM, operators in third countries will have to monitor their emissions based on rules developed in the EU and to be laid down in EU legislation. These operators will be in one of the following situations:

- Some operators will already have gained experience with monitoring, reporting and verification of their emissions either because there is already some form of carbon pricing in their jurisdiction (an ETS or a carbon tax) which requires MRV, or because they have implemented projects which require MRV, such as under CDM or a voluntary offsetting system such as the VCR. There are some sub-categories regarding the MRV system used:
 - MRV systems that are highly compatible with the EU ETS approaches;
 - MRV systems with approaches strongly deviating from the EU ETS ones.
- Some operators may be familiar with basic MRV principles because either they were asked to contribute data to the national GHG inventories under the IPCC guidelines, or because they monitor their emissions for purposes such as international sectoral data collection initiatives⁸⁷ or for general CSR reporting. In this case it can be conservatively assumed that monitoring may be carried out with out formalised guidelines.
- Many operators may have no MRV experience at all.

In order to better understand these groups of operators and for tailoring the CBAM's MRV rules to the needs of all these groups, some of the existing MRV rules of other jurisdictions were reviewed. However, this effort had to be limited to a small sample of systems, because usually system descriptions are only available in the jurisdiction's language. Nevertheless, we are confident that this gives a representative overview for the purpose of this discussion note. We have in particular corroborated this assumption by publications⁸⁸ by ICAP and

⁸⁷ E.g. the “getting the data right” of the Cement Sustainability Initiative (<https://www.wbcsd.org/Sector-Projects/Cement-Sustainability-Initiative>), the Worldsteel data collection (see footnote 86), or the international aluminium institute's statistics (<https://international-aluminium.org/statistics/greenhouse-gas-emissions-aluminium-sector/>)

⁸⁸ In particular the following:

- PMR: “Developing Emissions Quantification Protocols for Carbon Pricing – A Guide to Options and Choices for Policy Makers”; <https://openknowledge.worldbank.org/handle/10986/34388>
- PMR: “Designing Verification and Approval Systems - A Guide to Designing Systems for Carbon Pricing Instruments”, <https://openknowledge.worldbank.org/handle/10986/31324>
- ICAP & PMR: Emissions Trading in Practice: A Handbook on Design and Implementation (2nd Edition), <https://icapcarbonaction.com/en/publications/emissions-trading-practice-handbook-design-and-implementation-2nd-edition>
- ICAP: Emissions Trading Worldwide: 2022 ICAP Status Report, <https://icapcarbonaction.com/en/publications/emissions-trading-worldwide-2022-icap-status-report>

the Worldbank's PMR, which are fora for international cooperation in the area of emissions trading and carbon pricing. We are furthermore aware that also the European Commission is supporting various projects in third countries regarding the development of emission trading. The overall conclusions which can be drawn based on these sources are as follows:

- Overall, all MRV systems follow the same principles as the IPCC guidelines (see section 3.3) and are based on the same two generic approaches (calculation based on quantity of fuels and materials and emission factors) or continuous measurement. This is entirely compatible to the EU ETS approaches.
- Systems differ in particular in the detailed requirements, e.g. whether there are specified requirements for the measurement instruments used, and for determining the emission factors (e.g. if there are specific requirements for sampling and laboratory analyses like in the EU ETS or if that is left to the expertise of the operators). Some systems use only an emission factor, while others differentiate by using separate oxidation/conversion factors besides the emission factor. Many systems use the factor $44/12=3,667$ for conversion from C to CO₂, while the EU ETS and some others use the figure $44,009/12,011=3,664$ based on more precise atomic weights.
- Emissions from biomass (also if part of alternative fuels or waste derived fuels) are generally zero-rated. The additional requirement of sustainability criteria appears to be a unique approach in the current EU ETS.
- Not all systems have clearly defined tiers or minimum uncertainty levels to be achieved. Consequently, many systems do not have a requirement for continual improvement.
- Most systems require an installation-specific monitoring plan to be followed, but additional requirements such as the need for an internal control system and quality assurance measures are sometimes not included.
- Most systems prefer the calculation based approach, as this is simpler to apply and less prone to mistakes by operator's staff. The exception to this rule are systems in the USA and some other systems that follow their example. Those put more emphasis on continuous emission measurements systems (CEMS).
- Further differences are in the coverage of sectors and greenhouse gases. However, it is general consensus to include CO₂ emissions in general, and N₂O in nitric acid production and PFCs in primary aluminium production.
- Furthermore some systems require operators to report indirect emissions from electricity consumed.
- Rules for attributing emissions to "sub-installations" or to products are usually not found in these MRV rules.

• ICAP: A Guide to Linking Emissions Trading Systems,
<https://icapcarbonaction.com/en/publications/guide-linking-emissions-trading-systems>

- Third-party verification is almost universally applied, although significant differences exist. If verifiers require a form of approval, it is usually accreditation under ISO 14065. However, it is also possible that authorities accept other verifiers. Also the verifiers are not always contracted by the operators, but sometimes by the government.

From the literature cited in footnote 88 and from the project team's experience (workshops, projects) we concluded that the MRV systems of many currently already existing or planned emission trading schemes are strongly inspired by the EU ETS, in particular because there is a large set of guidance documents available on the Commission's website. This is in particular the case for the EU accession candidates and neighbourhood countries, where the Commission is providing capacity building. However, the following MRV systems were found to merit specific commenting:

- **US EPA mandatory GHG reporting and Californian Cap and Trade:**
Since the Acid Rain program, the US has strong experience in CEMS-based monitoring. Consequently, the reporting rules require CEMS as the principle methodology. However, EU ETS-like calculation methodologies are known as well. The EPA's Regulation⁸⁹ contains very detailed quality control measures for this purpose. It furthermore requires emissions of CH₄ and N₂O be taken into account from combustion activities based on emission factors. Although reporting is done annually, more data than in the EU ETS is required, in particular monthly emission values and some production figures for corroboration of the emissions data. Although most input data is used in US units, the final results (GHG emissions) are to be provided in metric tonnes.
Despite these differences, the system appears compatible to EU ETS and CBAM requirements.
- **Chinese national ETS:** At this point in time, only the power sector is included. There exist draft guidelines for monitoring of some industrial sectors, but they are not publicly available. The Commission has been cooperating with China for several years on ETS issues and has provided ample expert support. It is therefore assumed that final monitoring guidelines will follow similar approaches as in the EU ETS. For the industrial sectors, it is known from the 7 pilot systems that indirect emissions related to electricity consumption are to be reported.
- **Korean ETS:** No detailed MRV rules were found in ETS literature. It is known that the rules build on the earlier GHG Target Management System (TMS). They are, however, expected to be in line with international standards. Like in China, indirect emissions are to be reported.

Besides these carbon pricing systems put in place by governments, also the private sector has developed MRV methodologies, in particular for voluntary offset projects. The most relevant one is the UN-supervised CDM (Clean development

⁸⁹ <https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-98?toc=1>

mechanism). We have furthermore taken into account the VCR (Voluntary Carbon Standard). The latter, however, states on the website⁹⁰ that the methodologies of the CDM and of the (Californian) Climate Action Reserve can be applied. All these systems basically apply the international standards cited already above, or apply similar approaches. We restrict therefore our considerations here on the CDM.

The **CDM methodologies** are developed on a case-by-case basis for each project. However, some recurring elements were put forward for general application in so-called tools. For the CBAM purpose, the following two are of particular interest:

- Tool 3 on determination of fuel consumption⁹¹: It uses the common calculation method based on fuel consumption and emission factors. However, compared to the EU ETS it applies a different order of preferred methods, which may be more appropriate to situations with lower budget for MRV and/or less experience in this area. In particular, data provided by the fuel supplier is generally preferred over default values. Laboratory analyses seem to be avoided as much as possible. The overall quality assurance measures required are very basic only.
- Tool 8 on CEMS⁹²: In principle compatible with EU ETS rules, too, although QA measures are much less elaborated. However, if strictly applied, they should be sufficient for the CBAM's purpose. QA requirements include periodic calibration of flow measurements against a primary device provided by an independent accredited laboratory, calibration and frequency of calibration according to manufacturer's specifications, and calibration of gas concentration against calibration gases that must have a certificate provided by the manufacturer and must be under their validity period.

All the points above are encouraging in that they show that around the world, if there is an MRV system already in place, the most essential elements are compatible, even if differing in detail. This means that any EU legislation in the field can be expected to be understood in principle in all those jurisdictions that already have some MRV system. It will be feasible by using guidance documents to make operators understand the additional (and possibly more stringent) MRV requirements necessary for the CBAM.

4.4 Possibilities for simplification of MRV rules

The implementation of the EU ETS MRV system has taken several years, and improvements to the legal framework have been made several times. The introduction of sub-installation level monitoring for the purpose of benchmark-based free allocation has made the system considerably more complicated.

⁹⁰ <https://verra.org/methodologies/>

⁹¹ <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v3.pdf>

⁹² https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-08-v2.0.0.pdf/history_view

Now, with the CBAM, these rules are not only copied, but in fact made even more complex by adding the embedded emissions of precursor materials and other indirect emissions to the number of items to be monitored, reported and verified. Now such new and complex system of requirements will meet producers in third countries which will be basically unprepared, except where they have already a monitoring system in place, either for doing some corporate responsibility reporting, for voluntary determining of carbon footprints of their products, or for the purpose of a carbon pricing instrument (ETS or carbon tax) in place in their jurisdiction. Even if they have some data available, it will in most cases be incompatible in some ways with the data requirements of the CBAM (e.g. in terms of system boundaries). Furthermore, there will not be a competent authority as in the EU ETS which will not only enforce correct application of the rules, but also often organises trainings and helpdesks.

Under these circumstances, it seems an absolute necessity to start with as much simplified requirements as possible, keeping in mind that improvements can still be introduced later (or they can be contained in the legislation from the start, but the requirements can become relevant gradually, allowing time to adapt).

Our initial ideas on simplification options include:

- Simplify the tier system (data source/quality requirements), or avoid it completely. As an alternative, a kind of hierarchy of “best available data sources” like in the free allocation rules could be introduced.
- If tiers are kept, require lower minimum tiers than EU ETS installations have to comply with for the transitional period, provided that the lowest tiers lead to conservative emission figures (i.e. no under-estimation of embedded emissions).
- If tiers are kept, increase the thresholds for the categories of installations.
- Simplify the requirements for specific tiers, e.g. for sampling and laboratory analyses.
- Require only simplified risk assessment and control system (provided there is third-party verification).
- Simplify the uncertainty assessment for measuring instruments. E.g. allow all instruments that are under national legal metrological control, or if they are used in commercial transactions.
- Consider simplified approaches to demonstrate sustainability criteria for biomass, or omit them completely.
- Allow alignment of reporting periods between the other MRV system and the CBAM.
- Etc.

5 RELEVANT PRODUCTION ROUTES FOR CBAM GOODS

Note on the history of this chapter:

As was explained in Chapter 1, most of this note was written before the provisional political agreement on the CBAM Regulation – and in particular its scope – was reached. It was intended to support the development of methodologies, of which production routes and involved precursors are an integral and essential element. The original version of this chapter was built on the CBAM scope as given by the Commission proposal, but exceeded it in some points where it became apparent during the consultants' work and discussions with stakeholders that full consistency of the methodology would require the careful consideration of precursor materials.

The final result of the political discussions as reached in December 2022 is neither fully in line with the Commission proposal nor with what was proposed in this note. In order to preserve the argumentation of this note for future use (e.g. as input to the review pursuant to Article 30 of the CBAM Regulation), its coverage of goods was kept largely unchanged. This is reflected in section 5.6.1, containing the consultants' conclusions on the scope of the CBAM pursuant to the arguments in previous sections. However, the note was updated in order to fully reflect the scope of the CBAM as provisionally agreed by the Colegislators. The agreed scope is shown in the final section 5.6.2.

In this section, we explore the different production routes for the goods currently listed in Annex I of the CBAM Regulation. A focus of the work is in particular to identify the relevant precursor materials for all complex goods, with a view to their explicit inclusion in the CBAM scope for creating legal certainty and comparability of carbon costs under EU ETS and CBAM.

The following data sources have been used for this chapter:

- Production processes have been looked up in the relevant BREF⁹³ documents;
- Import figures were taken from Eurostat⁹⁴ (note that orders of magnitude were deducted, not precise figures. They are presented as highly rounded figures for avoiding distraction);
- Contribution of precursors to embedded emissions were estimated based on typical consumption levels given in the BREFs, and EU ETS emissions from benchmark data, to the extent possible.

⁹³ BAT Reference documents, BAT being "Best Available Techniques" as defined by the IED (Industrial Emissions Directive). All BREFs can be found at the European IPPC Bureau, under <https://eippcb.jrc.ec.europa.eu/reference>

⁹⁴ EU trade since 1988 by HS2-4-6 and CN8 [DS-645593], years 2018 – 2021, EU-27

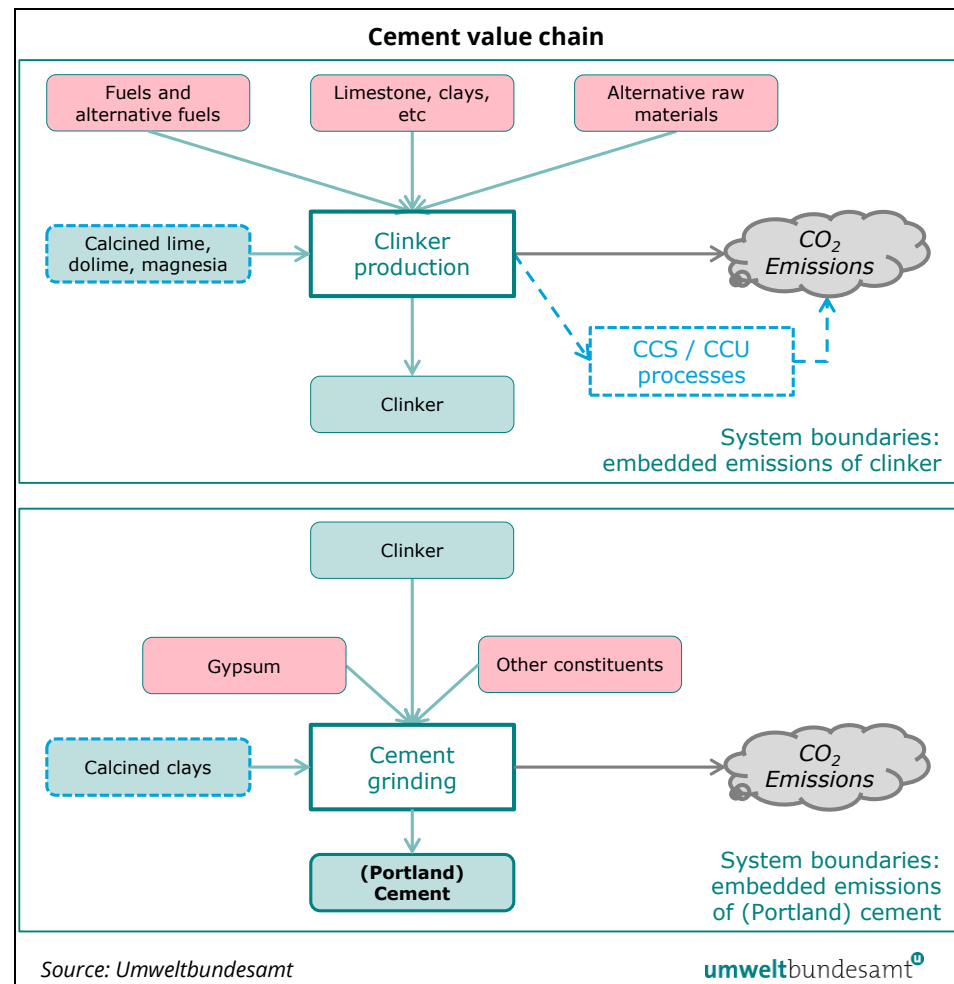
For the graphs presented in this chapter, the **following conventions** are applied:

- Production processes (for which monitoring of the direct emissions would take place) are shown as rectangles; Materials are shown in boxes with soft corners.
- Optional processes (e.g. CCS/CCU) or optional materials (e.g. calcined clays for cement) are shown in blue boxes. In particular CCS/CCU would not be taken into account for developing default values, but where an operator uses them, the related emissions or emission savings should be taken into account for determining actual embedded emissions.
- Materials which are considered to have no embedded emissions are shown in red boxes, materials with embedded emissions (including precursor materials and final products, i.e. goods under the CBAM) in green boxes. Simple goods are shown in normal font, complex goods in bold font.
- Input materials are presented without trying to be complete. This means that the focus is on materials which are relevant for demonstrating the differences between different production routes. As a consequence, less important input materials and in particular fuels are usually omitted in order to keep graphs simple.
- Electricity as input is shown only in cases where it is the main “precursor” of the process (i.e. in particular for electric arc furnaces and electrolysis processes). If the political choice is made to include indirect emissions in the CBAM obligation, then electricity would be relevant in all processes discussed.

5.1 Cement

5.1.1 (Portland) cement

Figure 5: Value chain of cement and system boundaries of the production processes. For a legend see explanations at the beginning of section 5.



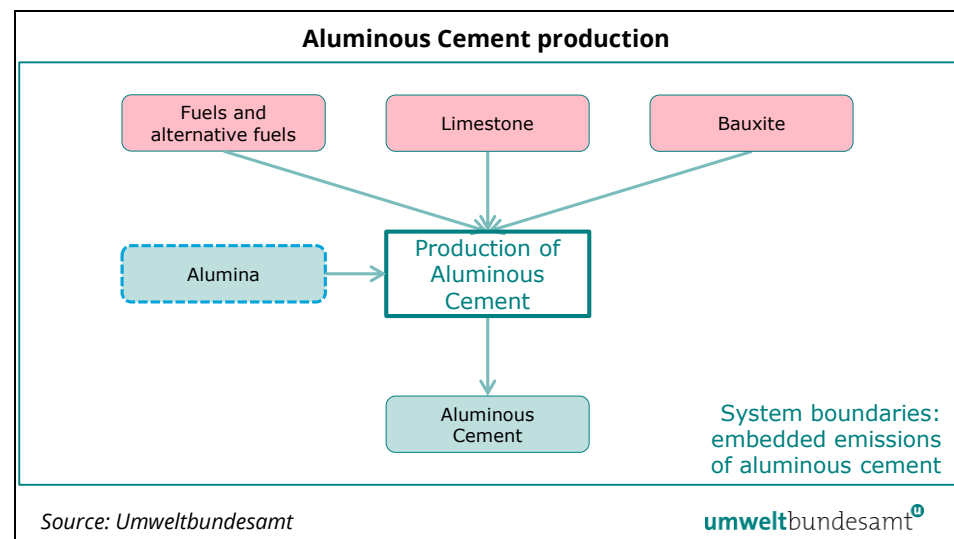
There will be one production route only. First, there will be the simple good “cement clinker”, for which the embedded emissions stem from the clinker production (“burning”) process (i.e. direct emissions from combustion of fuels and process emissions from decomposition of carbonates, plus indirect emissions from electricity consumption, if applicable). Secondly, cement is produced in the grinding plant (either within the same cement plant or in a standalone plant). Embedded emissions would come from the precursor clinker, and – if applicable – from the consumption of electricity. There are usually no significant direct emissions from this process.

Note: CCS/CCU processes are indicated in Figure 5 as an example. For keeping graphs reasonably simple, this is not shown in other sectors, but equally applicable there.

5.1.2 Aluminous Cement

In accordance with the provisional political agreement, aluminous cement (CN code 2523 30 00) was added to the scope of the CBAM. This is also referred to as “Calcium Aluminate Cement”. Therefore, a separate production route has to be defined for determining embedded emissions. The difference to conventional (Portland and other) cements is that basically the aluminous clinker is ground without further additives. Therefore there is no need to distinguish two production steps (clinker and cement), but to define only aluminous cement as a good under the CBAM. The second difference is that – although usual Bauxite is used as raw material – also alumina (see section 5.4.4.2) may be used, which would make the aluminous clinker a complex good. However, as currently Alumina is not within the CBAM scope, at this stage aluminous cement is considered a simple good.

Figure 6: Production process of aluminous cement and system boundaries. For a legend see explanations at the beginning of section 5.



5.1.3 Possible precursor materials

Cement and cement clinker are both already in the CBAM scope. Further precursors which should be included in the CBAM are calcined clays, which are used as additives in cement production for reducing the amount of clinker. Furthermore – if they should be included for the purpose of other industry sectors – it would be logical to include calcined lime, dolime and magnesia as relevant precursors in clinker production, as they could be (theoretically) used in this process for reducing direct CO₂ emissions.

Table 5: Information on potential relevant precursors for the cement sector. Furthermore, information on calcined lime, dolime and magnesia can be found in the section on iron and steel (section 5.2.2).

CN	Description	Import significance	Contribution to embedded emissions of cement
25070080	Other kaolinic clays	Imports of all clays under CN 2507 are about 3.5 Mt per year. However, for the sub-category 25070080, there is no data available at Eurostat.	Calcined clays would help reduce embedded emissions of cement. Additional Information will have to be asked upon import (calcined or not)

5.1.4 Proposed additional reporting requirements

According to the production route discussed above, the majority of embedded emissions of cement stem from the clinker production. While classic Portland cement contains about 95% of clinker, the European standard EN 197-1 defines cement types where the clinker content be as low as 20%. Declaring only the CN code for cement will therefore not be sufficient. It is proposed therefore that for cement an additional reporting requirement is added for the quarterly CBAM reports (transitional phase) and the CBAM declaration (definitive period):

- Clinker content (percent)

No additional reporting would be required for aluminous cement.

5.2 Iron & Steel

5.2.1 Production routes (overview)

Figure 7 gives an overview of the production routes and the various simple and complex goods involved in the steel industry regarding the production of carbon steel (i.e. steel without specific alloying elements). Figure 8 presents production routes for stainless and other (high) alloy steels. More details on the different production routes are given in sections 5.2.4.1 to 5.2.4.5.

Figure 7: Value chains and different production routes of carbon steel. For a legend see explanations at the beginning of section 5. BOF means basic oxygen furnace; EAF electric arc furnace; DRI direct reduced iron (often termed “HBI”, i.e. hot briquetted iron). Various combinations of these processes also exist. Regarding the embedded emissions of scrap, please see the note at the end of section 3.5.4. Only post-consumer scrap is assumed to have zero embedded emissions.

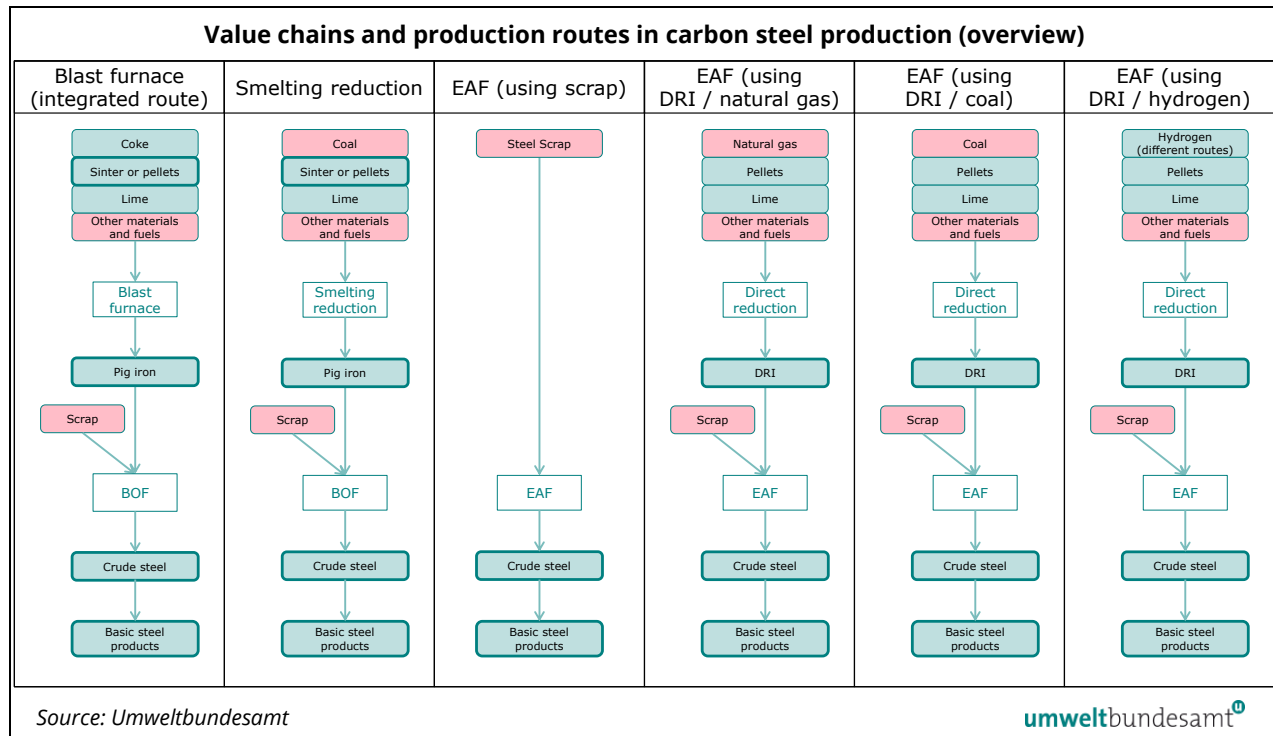
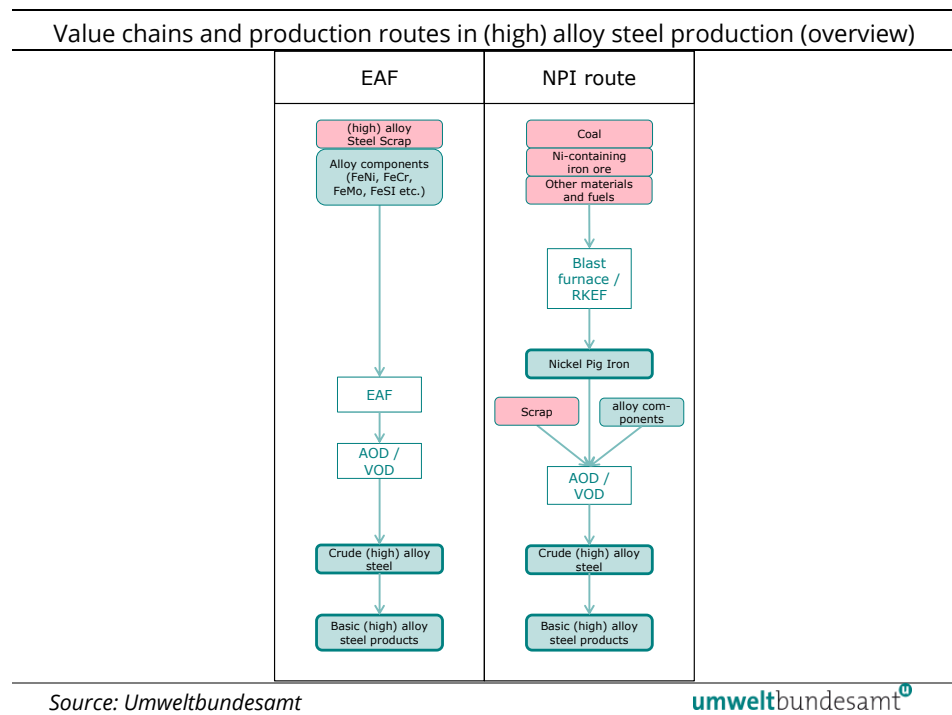


Figure 8: Value chains and different production routes of stainless and other (high) alloy steel. For a legend see explanations at the beginning of section 5. EAF means electric arc furnace; NPI Nickel Pig Iron, AOD Argon Oxygen Decarburisation, VOD Vacuum Oxygen Decarburisation, RKEF Rotary Kiln – Electric arc Furnace production route).



In this document we follow the industry's convention to refer to "normal" steel also as "carbon steel". "High alloy steel" where the total amount of elements other than iron and carbon exceeds 8%. However, in order to cover also steel qualities between carbon steel and high alloy steel, we usually refer to "(high) alloy steel".

"Stainless steel" is steel which contains at least 11% Chromium, and is therefore always included if high alloy steels are mentioned. However, as the CN classification usually distinguishes between stainless and other alloy steel, we mention them often separately.

5.2.2 Possible precursor materials

The following Table 6 gives an overview of potential precursor materials which are relevant in determining the embedded emissions of steel products. The table is meant as discussion input. The relevance for inclusion in the CBAM depends also on whether the materials contribute significantly to embedded emissions of other CBAM goods, which in turn depends also on whether they have themselves significant embedded emissions, and whether quantities imported into the EU justify the addition of complexity to the CBAM. These arguments are underpinned by estimations in Table 7.

Table 6: Precursor materials in the iron and steel sector for discussion of inclusion in the CBAM scope

CN	Description	Remarks
2704 00	Coke and semi-coke of coal, of lignite or of peat, whether or not agglomerated; retort carbon	
2713 11 00	Petroleum coke , non-calcined	Petcoke is relevant for the production of electrodes (but they are not proposed for inclusion, hence this argument is of limited concern).
2713 12 00	Petroleum coke, calcined	
2601 12 00	Agglomerated iron ores and concentrates (excl. roasted iron pyrites)	As in CN there is no "sintered/pelletised iron ores", this should be the correct code. Not clear if all products in this category have embedded emissions, or if some ores are purely mechanically compacted. To be confirmed with industry

CN	Description	Remarks
2518 20 00	Dolime: Calcined or sintered dolomite (excl. broken or crushed dolomite for concrete aggregates, road metalling or railway or other ballast)	Only the calcined lime, magnesia and dolime should be included, not the natural minerals (carbonates).
2519 90	Magnesia: Fused magnesia; dead-burned "sintered" magnesia, whether or not containing small quantities of other oxides added before sintering; other magnesium oxide (excl. natural magnesium carbonate "magnesite")	Note that these materials are also relevant in the building materials and other sectors. Their inclusion can be justified as the sector is also carbon leakage exposed, but the loss of free allocation may be challenged.
2522	Lime: Quicklime, slaked lime and hydraulic lime (excl. pure calcium oxide and calcium hydroxide)	In steel production, these materials are to some extent exchangeable. In the graphs only "Lime" is shown for simplicity.
7203 10 00	Ferrous products obtained by direct reduction of iron ore, in lumps, pellets or similar forms	DRI (Direct reduced iron, often in the form of HBI (hot briquetted iron), can be produced using natural gas, but in the future also by (green or other) hydrogen. Already in scope of CBAM Regulation
8545 11 00	Electrodes of graphite or other carbon, for electric furnaces	This CN code seems to be the one relevant for the steel industry (for EAF ⁹⁵ steel production)
7202 11	Ferro-manganese , containing by weight > 2% of carbon	These are only those CN codes in the 7202 group which are imported to the EU in relevant orders of magnitude
7202 19	Ferro-manganese, containing by weight <= 2% of carbon	
7202 21	Ferro-silicon , containing by weight > 55% of silicon	
7202 29	Ferro-silicon, containing by weight > 55% of silicon	
7202 30	Ferro-silico-manganese	
7202 41	Ferro-chromium , containing by weight > 4% of carbon	
7202 49	Ferro-chromium, containing by weight <= 4% of carbon	
7202 60	Ferro-nickel	

The following table presents estimated data on relevance of different potential precursor materials in steel making. It is to be noted that the embedded emissions do not include the actual carbon content of the material (e.g. coke) itself.

⁹⁵ Electric arc furnace

That would be relevant for the direct emissions at the point where the precursor is consumed. For example, the carbon content of coke would contribute to the direct emissions of the blast furnace process, and electrodes to the emissions of the electric arc furnace process, even if they are not included as precursor materials.

Table 7: Relevance of precursor materials in the iron and steel sector

CN	Imports significant?	Contribution of precursor's embedded emissions to embedded emissions of steel
2704 00 (Coke)	> 2 Mio t / yr	5 – 6%
2713 11 00 (Pet coke)	7 Mio t / yr	Like coke, if relevant at all
2713 12 00		
2601 12 00 Agglomerated iron ores)	30 Mio t / yr	Ca. 12%
2518 20 00 (Dolime)	150 000 t / yr	3 – 4%
2519 90 (Magnesia)	1 Mio t / yr	
2522 (Lime)	300 000 t / yr	
7203 10 00 (DRI)	3 Mio t / yr	Overwhelming part of total emissions in EAF/DRI route, but smaller than emissions in the blast furnace route. No data in BREF.
3801 (graphite)	100 000 t / yr	Electrode use ⁹⁶ : 2 – 6 kg / t steel → rather not significant
3801 30 00 (electrode paste)	20 000 t / yr	
8545 11 00 (electrodes)	70 000 t / yr	
8545 19 00 (other electrodes)	170 000 t / yr	
7202 1 Ferro-manganese	440 000 t / yr	According to a study for Eurofer, in the example of a typical stainless steel ⁹⁷ , precursors contribute 87 % with typical EU production methods, and even more where the NPI production route is used ⁹⁸ .
7202 2 Ferro-silicon	470 000 t / yr	
7202 3 Ferro-silico-manganese	630 000 t / yr	
7202 4 Ferro-chromium	550 000 t / yr	
7202 6 Ferro-nickel	210 000 t / yr	

⁹⁶ Based on BREF Iron & Steel production (2012)

⁹⁷ "Grade 304", 18 % Cr, 8 % Ni, 1,4 % Mn, 0,03% C

⁹⁸ The study assumes the inclusion of indirect emissions

5.2.3 Conclusions (iron & steel)

Table 8: Proposal for treatment of precursor materials in iron & steel sector

CN	Include in CBAM (Annex I)?
2704 00 (Coke)	For optimal emission coverage, inclusion should be considered
2713 11 00 (Pet coke)	No, except if relevant in the sector (tbc)
2713 12 00	
2601 12 00 Agglomerated iron ores)	For optimal emission coverage, inclusion should be considered
2518 20 00 (Dolime)	The following arguments seem relevant: • Contribution to embedded emissions of steel are relevant, but making the system more complex • Imported amounts small (cheap and heavy materials) • The material is relevant to other sectors (building materials, refractories), inclusion in CBAM would reduce their free allocation – could be rather controversial For optimal emission coverage, inclusion should be considered.⁹⁹
2519 90 (Magnesia)	
2522 (Lime)	
7203 10 00 (DRI)	Already included – However, different embedded emission factors for different production routes will be important
3801 (graphite)	Proposal: Do not include in CBAM scope, and neither in calculation of embedded emissions of steel products. This avoids unnecessary complications. However, this non-inclusion as precursor does not prevent that the carbon content of electrodes contributes significantly to the direct emissions of the EAF process.
3801 30 00 (electrode paste)	
8545 11 00 (electrodes)	
8545 19 00 (other electrodes)	
7202 1 Ferro-manganese	For optimal emission coverage, inclusion of these ferro-alloys should be considered.
7202 2 Ferro-silicon	
7202 3 Ferro-silico-manganese	
7202 4 Ferro-chromium	
7202 6 Ferro-nickel	

⁹⁹ Politically, this inclusion may be difficult. As alternative, it could be considered to include the materials only in the calculation of embedded emissions, but to not include these materials explicitly in the CBAM scope. However, this may be legally impossible due to unequal treatment considerations,

5.2.4 Steel production routes, system boundaries and relevant precursors

5.2.4.1 Blast furnace route (integrated steel making)

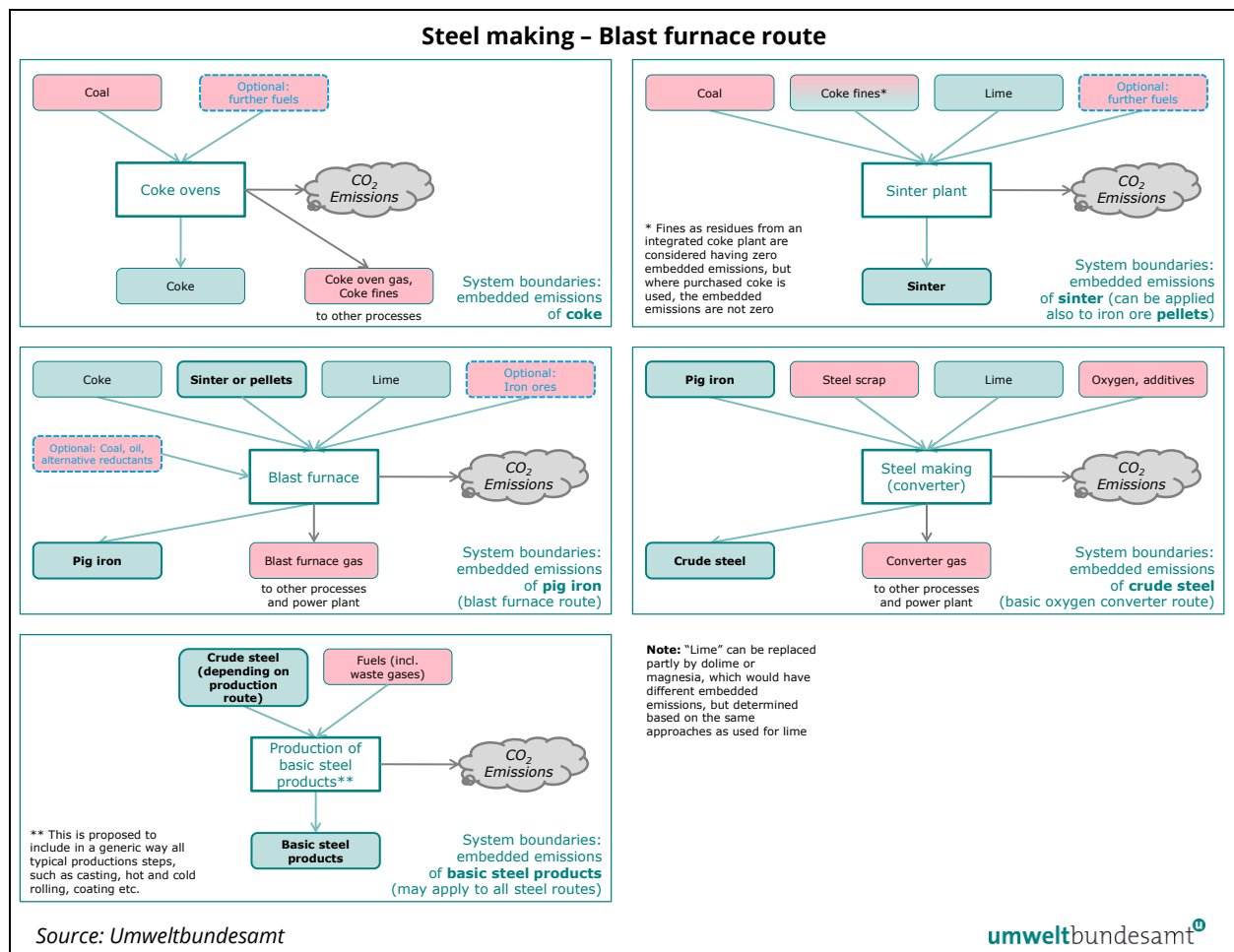
Figure 9 presents the relevant processes of the blast furnace steel making route:

- Production of coke;
- Production of sinter. This is overall similar to the production of iron ore pellets, although the latter usually takes place near the mining site, while sinter is produced usually at the steel plant. While the input materials and fuels may be different, the overall process description of the figure will apply;
- The blast furnace process, resulting in pig iron¹⁰⁰ (or “hot metal”);
- Steel making in the converter process, resulting in crude steel¹⁰⁰;
- Production of basic steel products¹⁰⁰ from crude steel, which means in principle all kinds of forming and finishing steps.

Some of these steps (in particular the finishing steps) will apply also to the other steel making routes. It is therefore important that the rules for determining embedded emissions provide a modular approach which allows these production process steps. This can be accomplished in particular by defining the relevant intermediate materials (pig iron, crude steel) as precursors for the final products, and by making clear that the appropriate production processes must be chosen. Where the process is unknown, a “process independent” route with a very conservative default value of embedded emissions will have to apply.

¹⁰⁰ More precise product definition in terms of CN codes may be required. It is proposed to assume here that all steel products would be hot-rolled, as approximation for all kinds of energy consuming treatments after crude steel production.

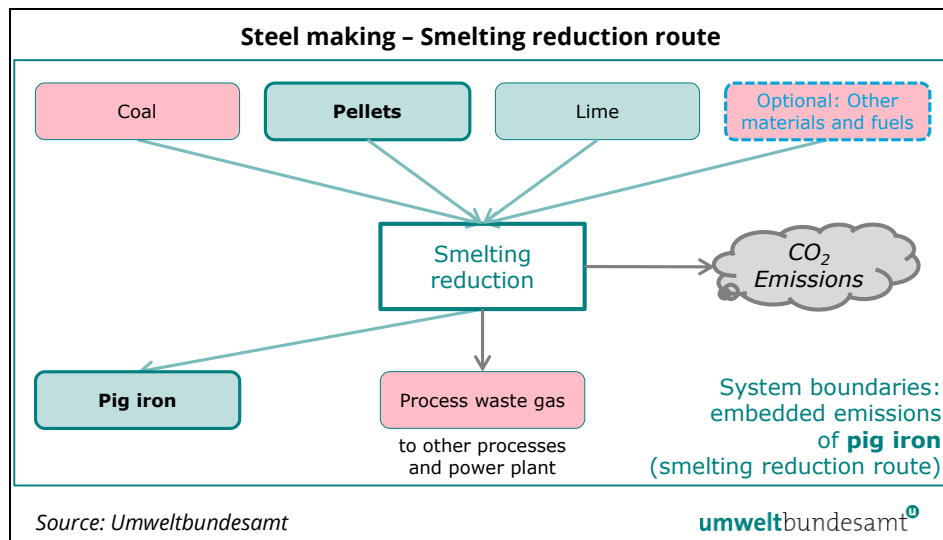
Figure 9: System boundaries of the individual processes involved in the classical blast furnace route of steel making. Regarding the embedded emissions of scrap, please see the note at the end of section 3.5.4. Only post-consumer scrap is assumed to have zero embedded emissions.



5.2.4.2 Smelting reduction

Figure 10 shows the boundaries of the smelting reduction process for producing pig iron. The system boundaries for the last steps (from pig iron to crude steel to basic steel products) are shown in Figure 9 and not repeated here. Coke production is not relevant. Production of pellets is usually necessary (similar process as sinter production), but usually done off-site (i.e. pellets are purchased).

Figure 10: System boundaries of the individual processes involved in the smelting reduction route of steel making.



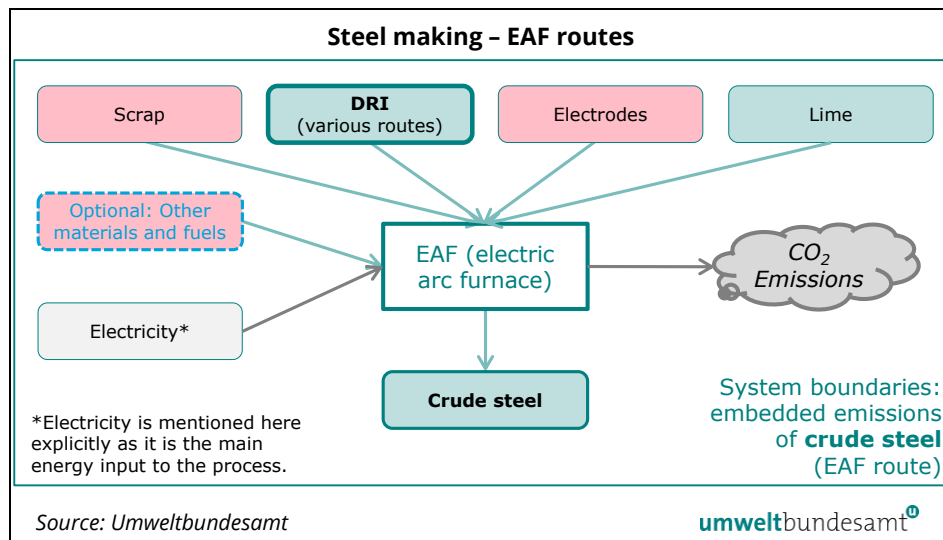
5.2.4.3 EAF routes

There are several different routes using the electric arc furnace (EAF) which can be summarised as “EAF routes”. The most frequent case is that there is only scrap¹⁰¹ used and no DRI (this is represented as separate production route in Figure 7). Where significant amounts of DRI (or even almost only DRI) are used, one of the “EAF/DRI” routes applies. The production processes for DRI are shown in section 5.2.4.4. Except for DRI use, the EAF production routes are identical and can therefore be shown jointly in Figure 11. The system boundaries for the last steps (from pig iron to crude steel to basic steel products) are already given in Figure 9 and not repeated here.

Electricity is an important input to all processes in CBAM to be taken into account if indirect emissions are relevant. It should therefore be included in all production processes shown in this section, but is usually omitted to keep graphs simple. However, it is mentioned explicitly in the EAF case in order to highlight that it is the main input to the process, while other steel production routes require reducing agents, as they start from iron ore (i.e. oxides) and not from metallic iron (scrap or DRI).

¹⁰¹ Regarding the embedded emissions of scrap, please see the note at the end of section 3.5.4.

Figure 11: System boundaries of the EAF processes for steel production. Regarding the embedded emissions of scrap, please see the note at the end of section 3.5.4. Only post-consumer scrap is assumed to have zero embedded emissions.

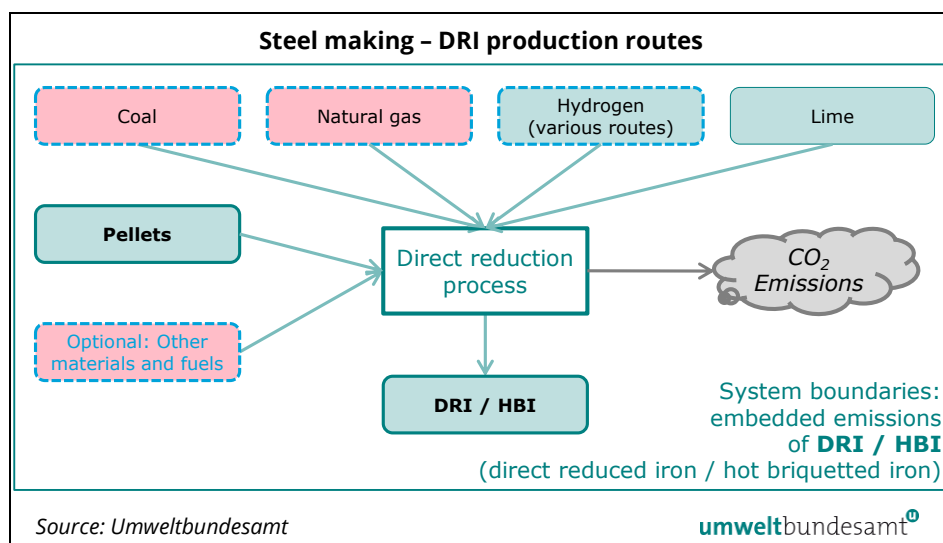


5.2.4.4 DRI production routes

Figure 12 presents the system boundaries of the DRI production, which is usually used as feedstock for EAF processes (section 5.2.4.3). Although there are several different processes used in practice, using usually only one of the main inputs (natural gas, coal or hydrogen), the high-level system boundaries can be assumed to be very similar, i.e. one graph can cover them all.

At this time, the production routes using natural gas or coal are predominant. Production routes using hydrogen will play a major role in coming years or decades in order to decarbonise the steel industry and are therefore to be included for CBAM purposes already now.

Figure 12: System boundaries of DRI production



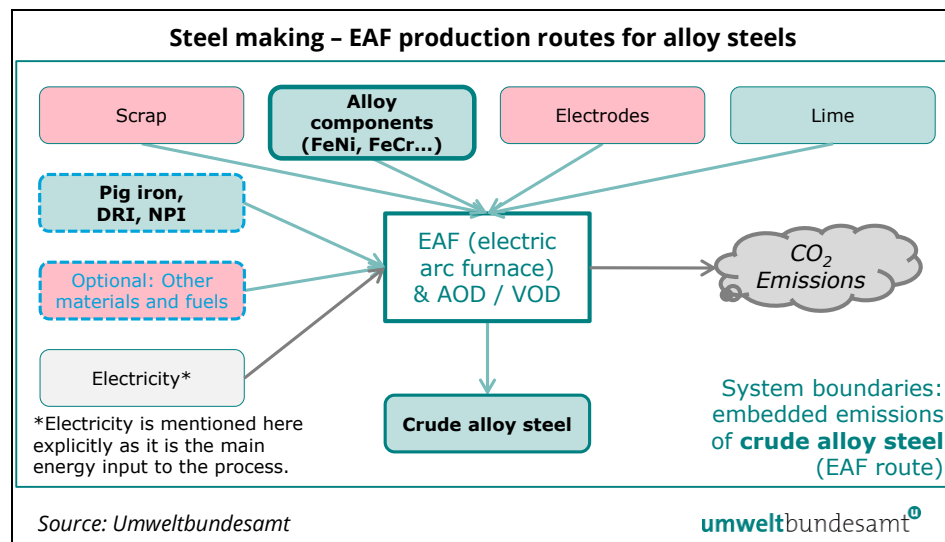
5.2.4.5 Production of alloy steels

Figure 13 outlines the system boundaries for the production of stainless and other (high) alloy steels. The main difference to the production routes shown in sections 5.2.4.1 to 5.2.4.4 is the need to input alloying elements. These are contained either in (high alloy) scrap¹⁰², in components such as ferro-nickel (FeNi), ferro-chromium (Fe-Cr) etc., or added as pure metals, if required. A special case is the use of NPI (Nickel Pig Iron) in some installations outside the EU, which is basically a pig iron derived from an iron ore with significant nickel content. Its production is in principle comparable to the production of normal pig iron as given in section 5.2.4.1, although sometimes rotary or other kilns are used instead of blast furnaces.

Except where liquid NPI is used, all other production routes require an EAF for melting the scrap and other components. Thereafter, excess carbon is removed in a converter (either Argon Oxygen Decarburisation (AOD) or Vacuum Oxygen Decarburisation (VOD)). Because of the similarities of the production routes which mainly differ in their specific inputs needed to achieve a specific alloy grade, only one process description is required.

For the application of default values for the alloying elements, a simplified approach will have to be developed, because compounds like FeNi and FeCr are traded with various contents of the relevant alloy element. It is proposed that such simplification will assume a default value per percent alloy element, independent of whether the element is contained in a ferro-alloy or used in elemental form.

Figure 13: System boundaries of the production of stainless and other alloy crude steel



¹⁰² See note at the end of section 3.5.4 for the distinction of post-consumer scrap and process scrap.

5.2.4.6 Production of ferro-alloys

According to the BREF¹⁰³ document on non-ferrous metals production, there are three production routes which cover in principle all ferro-alloys, and which differ in the element used for reducing the ores to give the desired alloy:

- Carbothermic reduction: metal oxide + carbon → metal + carbon monoxide
- Silicothermic reduction: metal oxide + silicon → metal + silicon oxide
- Aluminothermic reduction: metal oxide + aluminium → metal + aluminium oxide

For simplicity, in the following we describe only one generic process, with each of the possible reducing agents shown as optional input. Notably, all these input are potentially complex goods themselves:

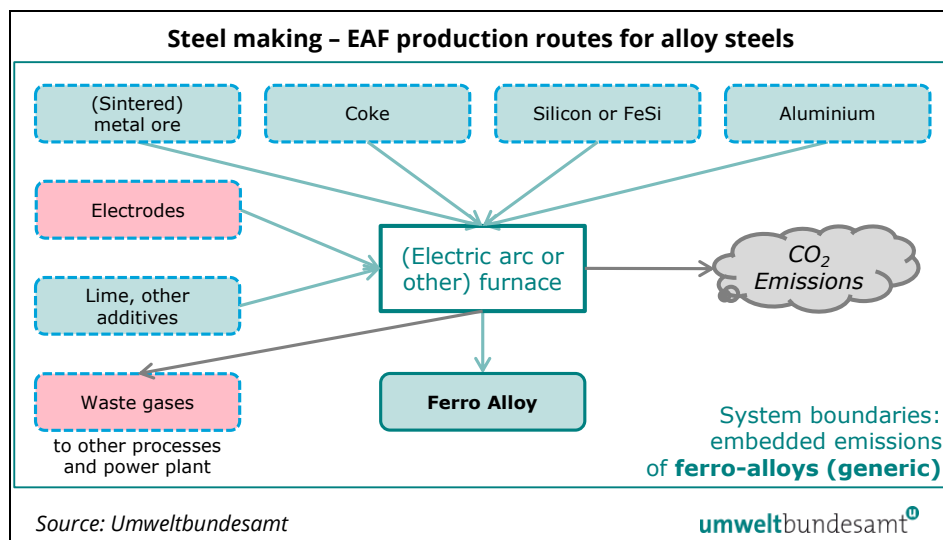
- For the carbothermic reaction, coke would be used;
- Silicon (or in the form of FeSi) would be produced by carbothermic reaction;
- Aluminium would be produced as given in section 5.4.

Furthermore the ores containing the mentioned metal oxides often require a palletisation or sintering process. The process given in section 5.2.4.1 and Figure 9 (sub-figure on “sinter plant”) should be considered to be applicable *mutatis mutandis*. Therefore, in Figure 14, all these potential precursors are shown as complex goods.

Lime and other additives may be required to build good slags and as fluxing agents. Where the reaction is carried out in an electric arc furnace, electrodes will be a further source of emissions. When using closed furnaces, waste gases can be recovered for further use. Therefore lime, electrodes and waste gases are indicated as optional, too.

¹⁰³ See footnote 93

Figure 14: Generic system boundaries of the production of ferro-alloys.



5.2.5 Proposed additional reporting requirements

There are three parameters which have a strong impact on the embedded emissions of iron and steel products: The production route, the amount of (post-consumer) scrap used for production, and the content of alloying elements. These are not reflected in the CN classification. It is therefore proposed that for the purpose of the quarterly CBAM reports (transitional phase) and the CBAM declaration (definitive period), the following items should be reported:

- The production route, in particular whether blast furnace or electric arc furnace is used, and the main reducing agent (coal, coke, natural gas, hydrogen);
- The steel grade, either using the nomenclature given in EN 10025 and EN 10088, or by listing the percentage of each alloying element;
- In case of precursor alloys: the percentage of the main element content;
- The percentage of post-consumer scrap used for the steel product imported;
- In case of ferro-alloys, the content of the respective alloy elements and carbon content.

5.3 Fertilizers

5.3.1 Production routes

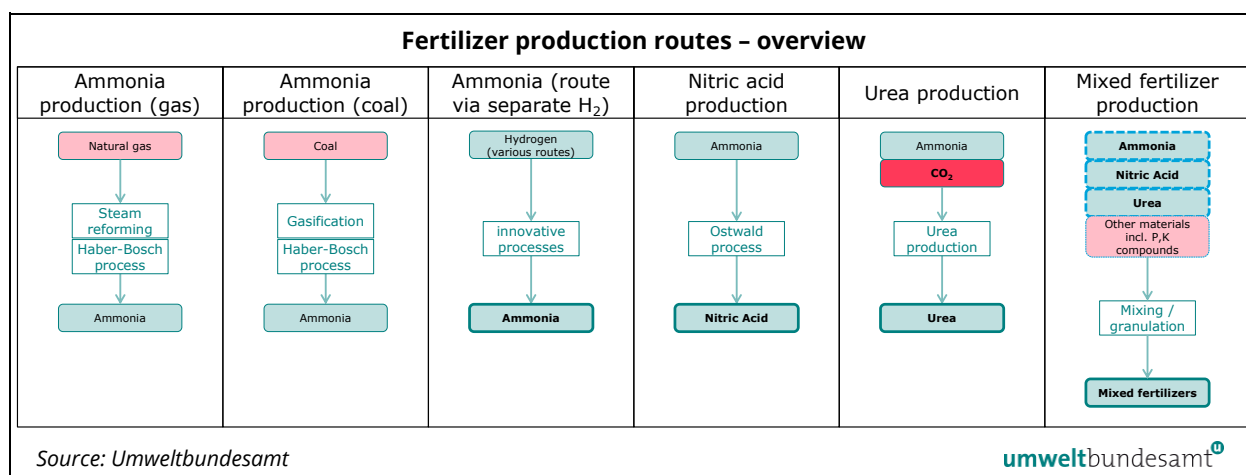
The following points are issues specific to the fertilizer sector:

- Only nitrogen (N)-containing fertilizers have significant embedded emissions and are therefore included in the CBAM. The other main nutrients (potassium (K) and phosphorous (P)) are not relevant in that regard.

- European fertilizer legislation¹⁰⁴ requires that the content of N (in its different forms, as ammonium (NH_4^+) or nitrate (NO_3^-) or other (organic) forms¹⁰⁵) is clearly indicated on the packaging or in accompanying sales documentation in case of bulk deliveries. These content values will have to be used to determine embedded emissions of any mixed fertilizer.
- In the monitoring of emissions from nitric acid production, not only CO_2 , but also N_2O emissions have to be included.
- The production process of urea consumes CO_2 which is usually delivered from other production processes on site, in particular from ammonia production, i.e. the process is a “carbon sink”. The rules for determining embedded emissions will have to reflect this fact. However, in the EU ETS these rules are currently not yet fully developed. As soon as they are available, the rules under the CBAM should be aligned.

Figure 13 gives the principle production processes. It is worth noticing that with increasing use of hydrogen (starting from renewable energy sources, see routes given in section 0), also mixed production routes for ammonia are applied (i.e. where hydrogen from separate (green) production is fed into the Haber-Bosch process).

Figure 15 Relevant value chains and production routes in the fertilizer sector



¹⁰⁴ Regulation (EU) 2019/1009 of the European Parliament and of the Council of 5 June 2019 laying down rules on the making available on the market of EU fertilising products
ELI: <http://data.europa.eu/eli/reg/2019/1009>

¹⁰⁵ Another form of nitrogen fertilizer is CaCN_2 (calcium cyanamide), but it is assumed that this plays no role in the EU (at least its production process based on calcium carbide is not given in the BREF document).

5.3.2 Precursor materials and value chain

Table 9: Precursor materials and final products in the fertilizer sector for discussion of inclusion in the CBAM scope

CN	Description	Remarks
2804 10 00	Hydrogen	Although relatively expensive, separately produced “green” hydrogen is increasingly used. For details see section 0
2814	Ammonia , anhydrous or in aqueous solution	Already in proposal
2808 00 00	Nitric acid ; sulphonitric acids	Already in proposal
3102	Mineral or chemical nitrogenous fertilisers (excl. those in tablets or similar forms, or in packages with a gross weight of ≤ 10 kg)	Already in proposal
3102 10	Urea	Included above in 3102
3102 30	Ammonium Nitrate	Included above in 3102
3105	NP, NK, NPK fertilizers Mineral or chemical fertilisers containing two or three of the fertilising elements nitrogen, phosphorus and potassium; other fertilisers; goods of this chapter in tablets or similar forms or in packages of a gross weight not exceeding 10 kg	Already in proposal
Except 3105 60 00	Except: Mineral or chemical fertilisers containing the two fertilising elements phosphorus and potassium	
2834 21 00	Nitrates of potassium	

5.3.3 Conclusion

For this sector, the value chain is almost completely contained in Annex I of the Commission proposal for the CBAM Regulation. As an only exception, hydrogen is not listed, but was included by the provisional political agreement on the CBAM. However, under current production techniques, hydrogen is usually produced in an integrated process with ammonia, and not purchased on the market. Consequently, hydrogen imports do not need to be included in the CBAM Regulation (*at least not for purposes of the fertilizer sector*). However, for the decarbonisation of industry as a whole, demand for “green” hydrogen (i.e. hydrogen produced by electrolysis using electricity from renewable sources) will increase, in order to allow ammonia production with such hydrogen. This will lead to non-integrated ammonia production processes, and imports of hydrogen will become important. For avoiding large imports of non-green hydrogen, inclusion of hydrogen in the CBAM would therefore be useful, at least in the longer term.

5.3.4 Proposed additional reporting requirements

In order to explain the embedded emissions of mixed fertilizers, the CN code is not sufficient. Therefore, it is proposed to require sufficient information in the quarterly CBAM reports (transitional phase) and the CBAM declaration (definitive period), in particular the information required anyway under Regulation (EU) 2019/1009:

- content of N as ammonium (NH_4^+);
- content of N as nitrate (NO_3^-);
- content of N as Urea;
- content of N in other (organic) forms.

5.4 Aluminium

5.4.1 Production routes

Figure 16 gives an overview of the relevant production routes in the aluminium sector. The main difference between primary and secondary production is that the secondary process starts from aluminium scrap¹⁰⁶ (i.e. aluminium products collected for recycling), which is by far less energy intensive than primary smelting. The primary smelting starts from aluminium oxide (crude Bauxite which is processed to Alumina) and involves electrolysis. The CBAM embedded emissions thereby highly depend on indirect emissions. Furthermore, PFC emissions (CF_4 and C_2F_6) have to be monitored.

The primary processes differ in terms of precursors: In most modern smelters, pre-baked graphite electrodes are used. This baking process leads to significant emissions, for which an EU ETS benchmark is available. These anodes should therefore be considered precursors to be taken into account for embedded emissions. On the other hand, Söderberg cells require only a graphite containing paste, for which it will be difficult to define embedded emissions. Therefore it is proposed to treat this paste not as a precursor. However, it must be recalled that the direct emissions stemming from the consumption of the electrodes and electrode paste will still contribute to the embedded emissions of aluminium. A third option, “inert anodes” (carbon-free anodes) have been subject to research but seem to play no role in practice. Such production route is therefore not included here.

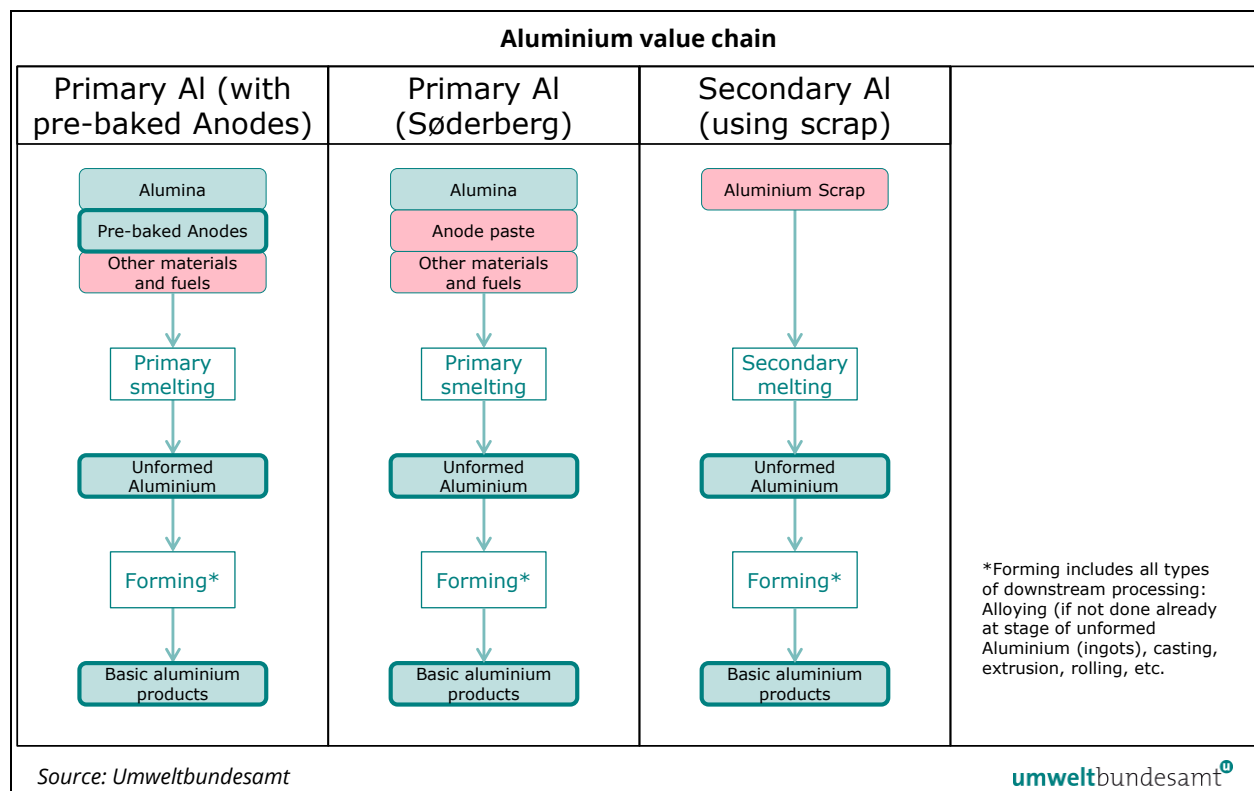
Like in the steel sector, it is proposed to introduce an intermediate product, “unformed aluminium”, after which diverse forming and finishing steps should be taken into account for all production routes. The exact definition of this intermediate, including identification of appropriate CN codes will be necessary.

Unlike in the steel sector, alloys play a relatively small role in the aluminium industry. As a simplification, it is proposed that in the calculation of embedded

¹⁰⁶ Regarding the embedded emissions of scrap, please see the note at the end of section 3.5.4.

emissions, the amount of alloy elements found in an aluminium product should be considered as the equivalent mass of primary aluminium.

Figure 16: Materials involved in the Aluminium sector; Scrap is indicated as raw material because no embedded emissions are assigned to it. For a legend see explanations at the beginning of section 5. Regarding the embedded emissions of scrap, please see the note at the end of section 3.5.4. Only post-consumer scrap is assumed to have zero embedded emissions.



5.4.2 Possible precursor materials

Table 10 lists important precursors in the aluminium production process, as well as some precursors relevant for producing electrodes (pre-baked anodes or electrode pastes). Table 11 provides an estimate regarding the relevance of these materials. Section 5.4.3 draws the conclusions for including precursors in the scope of the CBAM.

Table 10: Precursor materials in the Aluminium sector for discussion of inclusion in the CBAM scope

CN	Description	Remarks
2818 20 00	Aluminium oxide (excl. artificial corundum)	Alumina (Aluminium oxide)
2818 30 00	Aluminium hydroxide	The hydroxide not relevant
8545 19 00	Electrodes of graphite or other carbon, for electrical purposes (excl. those used for furnaces)	"Prebaked anodes"

CN	Description	Remarks
3801 30 00	Carbonaceous pastes for electrodes and similar pastes for furnace linings	Unclear how embedded emissions can be determined, because very different compositions are possible
2713 11 00 2713 12 00	Pet coke	Pet coke is a refinery product, i.e. it may be difficult to agree on an embedded emissions figure.
2708 10 00	Pitch obtained from coal tar or from other mineral tars	Production route (for embedded emissions) would need to be determined

Table 11: Relevance of precursor materials in the Aluminium sector

CN	Imports significant?	Contribution to embedded emissions of (primary) Aluminium
2818 20 00 (Alumina)	1 Mio t / yr	If indirect emissions included: 10% Otherwise: 33 – 40 %
2818 30 00 (Aluminium hydroxide)	300 000 t / yr	
8545 19 00 (electrodes)	170 000 t / yr	Electrodes: 2,5 % (if indirect emissions included), otherwise: 10%
3801 30 00 (pastes for electrodes)	20 000 t / yr	
2713 11 00 (pet coke) 2713 12 00	7 Mio t / yr	Small impact (<50% of electrodes)
2708 10 00 (pitch)	< 20 000 t/yr	

5.4.3 Conclusions (Aluminium)

Alumina should be included in the CBAM. The second precursor (pre-baked electrodes), should be included, too, as the baking process leads to significant emissions. However, electrodes themselves should be considered simple goods, i.e. their own precursor materials should not be further considered. This is mainly because there may be too many different composition options for these electrodes, and embedded emissions for some of the used materials may be difficult to determine. Based on the same consideration, electrode pastes for the Söderberg process should not be considered a precursor material.

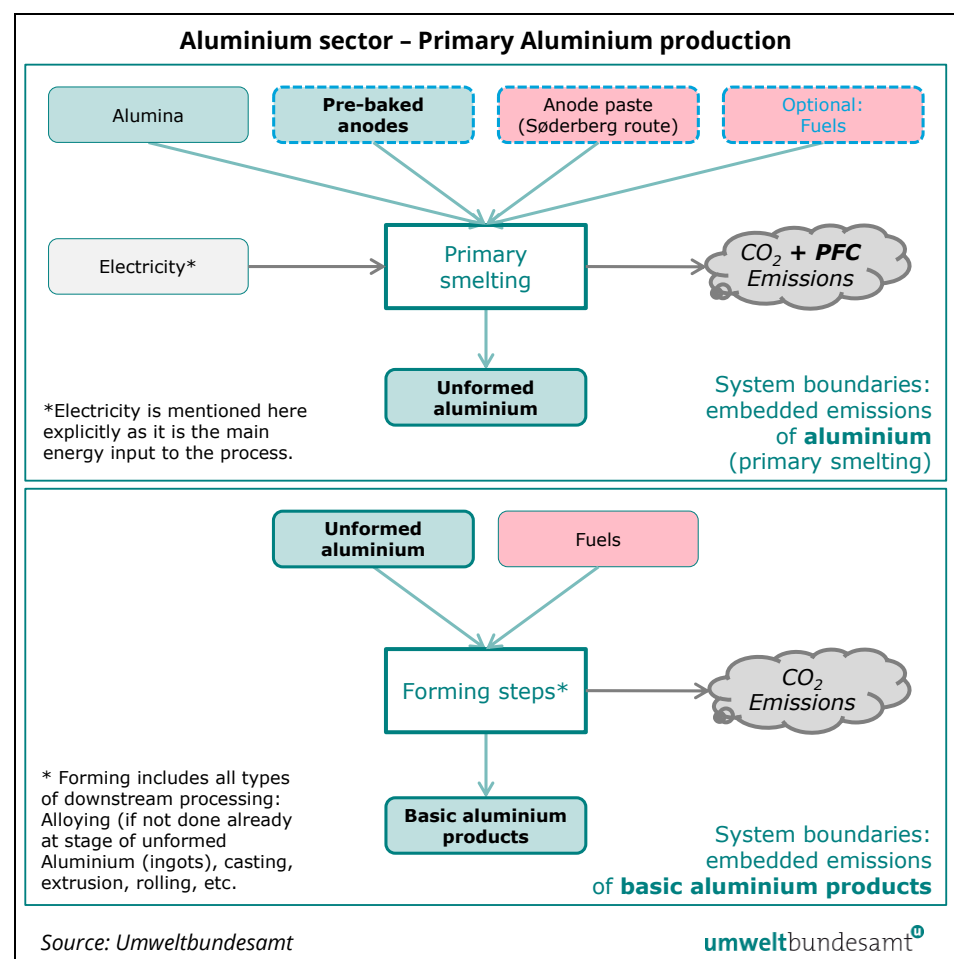
5.4.4 Aluminium production routes

5.4.4.1 Primary smelting

As mentioned above, the key features of primary smelting are the high electricity consumption, and the occurrence of PFC emissions. Figure 17 gives the system boundaries of the relevant production processes. The different smelting routes (pre-baked anodes, Søderberg, or inert electrodes) can be covered by the same figure. The difference is which of the electrode materials (indicated as optional) are used.

The forming process applies also to secondary aluminium.

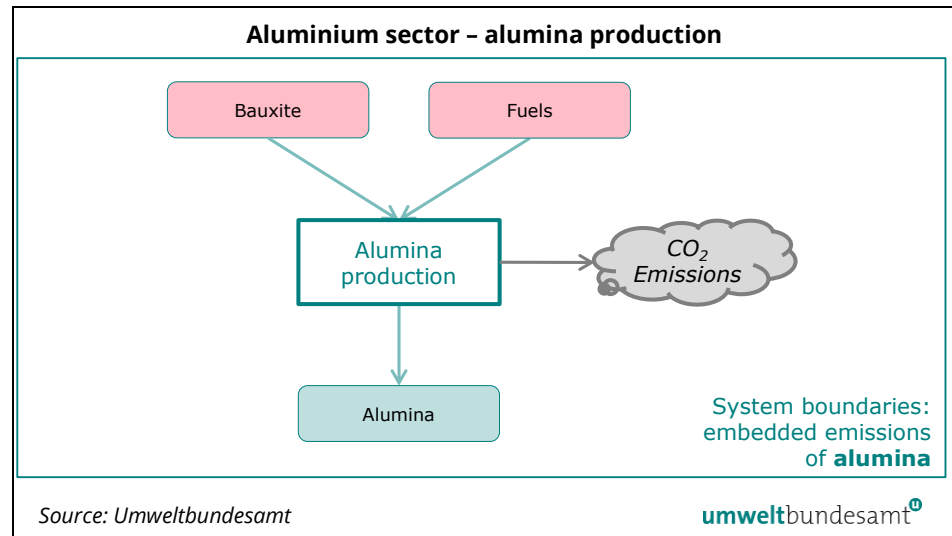
Figure 17: System boundaries of primary aluminium production



5.4.4.2 Alumina production

Figure 18 presents the system boundaries of alumina production (as precursor to primary aluminium smelting).

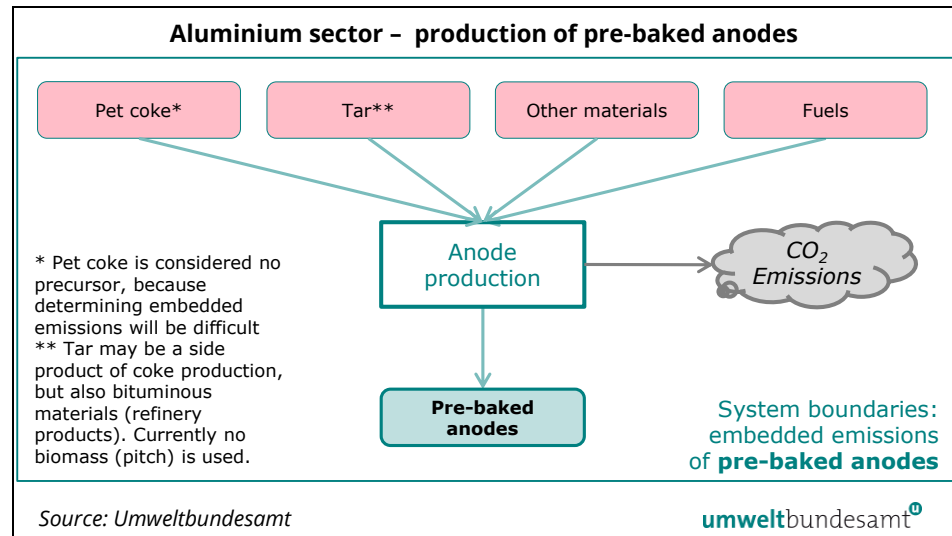
Figure 18: System boundaries of alumina production



5.4.4.3 Pre-baked anodes

Figure 19 gives the production process for pre-baked anodes. At this point, the proposal is to consider only coke as precursor (if used), because it should also be included in the CBAM due to the steel production routes. All other inputs should be considered to have zero embedded emissions.

Figure 19: System boundaries of the production of pre-baked anodes

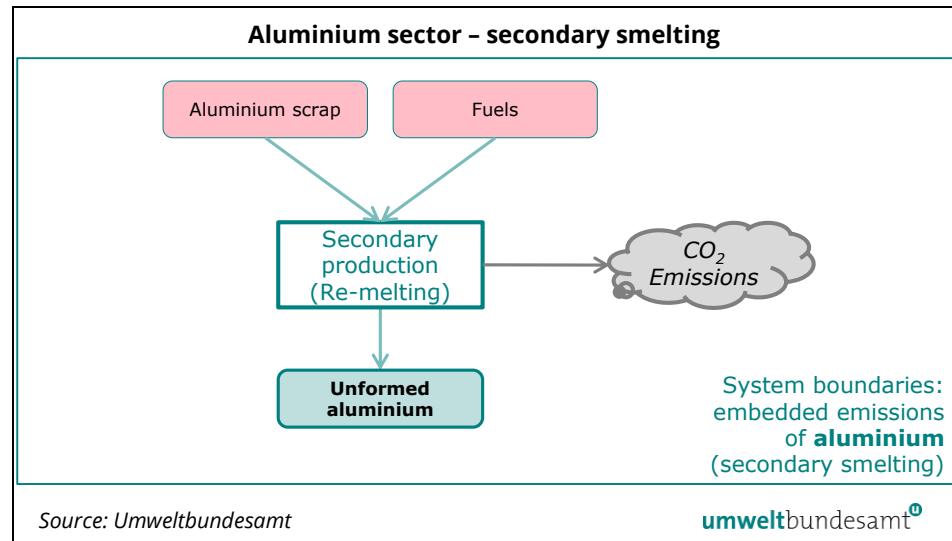


5.4.4.4 Secondary melting

Figure 20 presents the secondary aluminium melting process, based on aluminium scrap¹⁰⁷ to be recycled. Electricity input is of little impact, and only CO₂ emissions are relevant. The forming steps would be similar to those included above for primary smelting.

¹⁰⁷ Regarding the embedded emissions of scrap, please see the note at the end of section 3.5.4.

Figure 20: System boundaries of secondary aluminium production (recycling of aluminium scrap¹⁰⁷)



5.4.5 Proposed additional reporting requirements

The most important impacts on the embedded emissions stem from the production route (primary or secondary), and the amount of (post-consumer) scrap used for production. Alloying elements play a minor role, but might still be worth reporting. These are not reflected in the CN classification. It is therefore proposed that for the purpose of the quarterly CBAM reports (transitional phase) and the CBAM declaration (definitive period), the following items should be reported:

- The production route, in particular whether primary smelting takes place;
- The percentage of post-consumer scrap used for the aluminium product imported;
- If the total content of elements other than aluminium exceeds one per cent, the total percentage of such elements.

5.5 Hydrogen

5.5.1 Production routes

In Europe, 47% of produced hydrogen is used in refineries, 39% in ammonia production, and 14% in other chemical products and the metal industry¹⁰⁸. Over 90% of hydrogen is produced from hydrocarbons, primarily from methane^{109,110}. The choice of the hydrogen production process is directly linked to its end use. While stand-alone hydrogen production processes will in most cases be steam reforming plants (using methane), hydrogen used in refineries is produced by applying different processes. The most frequently used is catalytic reforming, where hydrogen is a *by-product*. Steam reforming of methane or light fractions as well as partial oxidation of various (often heavy) oil fractions are found as well.

However, hydrogen can also be produced by electrolysis, but this production seems still of a negligible order of magnitude, but the interest as well as the number of (pilot) projects is increasing fast. Furthermore, H₂ is a side product of Chlor-Alkali electrolysis. In a low-carbon society, however, the electrolysis of water will become of increasing importance, including considered as storage technology for renewable energy ("power to gas/liquid").

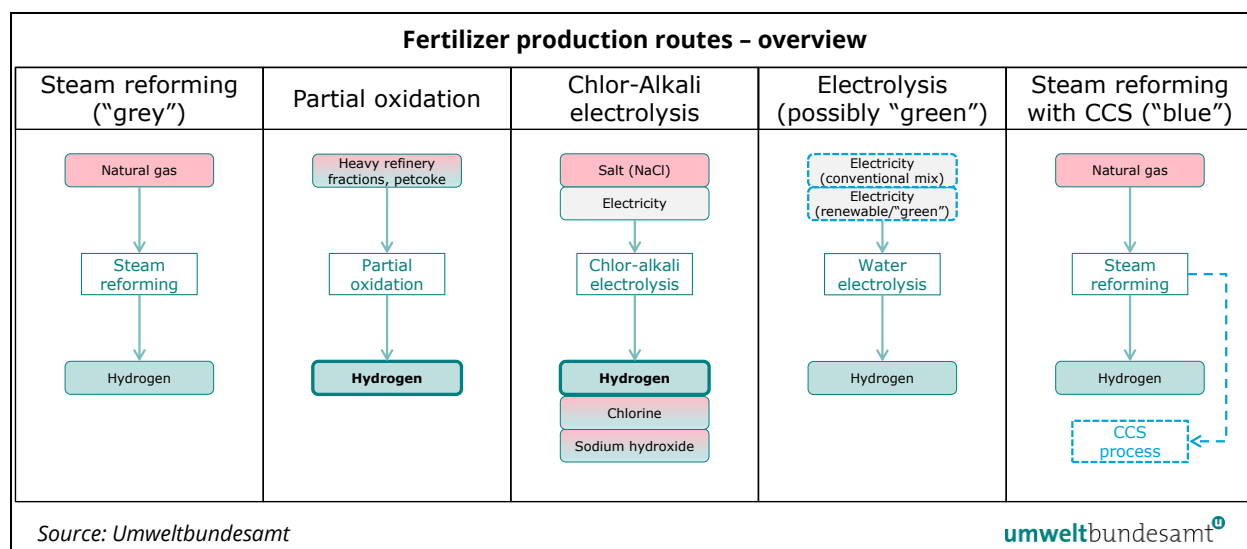
Figure 21 presents an overview of the production routes considered relevant for the CBAM. For the by-products shown in shaded fields, currently no methodology to allocate emissions are available.

¹⁰⁸ Figures are based on unpublished work carried out by part of the project team in 2017.

¹⁰⁹ A significant part of the remaining 10% may be based on heavy hydrocarbons or pet coke in refineries.

¹¹⁰ It must be noted that hydrogen used in ammonia production is mainly methane-based, and therefore a considerable share of the 90% indicated here correspond to ammonia production. When looking only at refineries and standalone hydrogen plants, the fraction of reforming will therefore be lower.

Figure 21 Relevant production routes for hydrogen



5.5.2 Materials to be included in the CBAM (incl. precursors)

Table 12: Proposal for inclusion of hydrogen in the CBAM scope

CN	Description	Remarks
2804 10	Hydrogen	

5.5.3 Conclusions (hydrogen)

No specific precursors would have to be included, but several production routes need to be taken into account. It will be useful to define different default embedded emissions values for the different production routes, so that importers can use them, provided the origin of the product can be identified and verified.

5.6 Summary of precursors and production routes

5.6.1 Consultants' conclusion on the CBAM scope

Table 13: Overview of production routes and precursors over all sectors discussed

Material	Production route	Precursors relevant	Remarks
Portland Cement		Cement clinker, Calcined clays	
Cement clinker		calcined lime, dolime and magnesia	
Calcined clays			
Aluminous cement		Alumina	
Calcined Lime, dolime or magnesia			Proposed for inclusion. Lime, dolime and magnesia are considered exchangeable
Basic steel products		Crude steel (different routes)	The step from crude steel to products is included in the EU ETS only via fall-back benchmarks
Crude steel	BOF route	Pig Iron / Hot metal (from blast furnace or smelting reduction); Lime; Alloys	Scrap as important input, but assumed to have zero embedded emissions ¹¹¹ , therefore not a precursor
	EAF routes	Eventually hot metal; DRI (various routes); Lime; Alloys	Scrap zero-rated ¹¹¹
DRI / HBI	From natural gas / coal	Sinter / pellets; Lime	
	From H ₂	H ₂ ; Sinter / pellets; Lime	For H ₂ production, see production routes below
Hot metal ("Pig Iron")	Blast furnace route	Coke; Sinter/pellets Lime; alloys	
	Smelting reduction	Sinter/pellets; Lime	
Alloys (FeMn, FeCr, FeNi etc.)		Depending on process: Sintered ore ¹¹² ; coke, Silicon or FeSi, Aluminium; Lime	
Coke		None	

¹¹¹ Note: Only the embedded emissions of post-consumer scrap are zero-rated. In the production process itself, scrap would not be zero-rated. This applies to all processes in general: Emissions of the production processes must be monitored covering all source streams.

¹¹² With possible adaptation to the specific metals contained in the ore.

Material	Production route	Precursors relevant	Remarks
Sinter / pellets		Coke, Lime	Assumed that in principle the same processes boundaries can be used for sinter and pellets, although for pellets usually no coke is involved
Hydrogen	Steam reforming ¹¹³		“grey” hydrogen; Natural gas as input theoretically, biogas is a possible zero-emission input; “brown” hydrogen if produced from coal
	Steam reforming with CCS or CCU		“blue” hydrogen; Natural gas as input
	Electrolysis		Important: Source of electricity. If renewable electricity: “green” hydrogen
	Chlor-Alkali electrolysis		Hydrogen is a by-product of Chlorine production – needs discussion how to attribute emissions to hydrogen
Ammonia	Classic Haber-Bosch process (Integrated)		Natural gas as input. No separate accounting for intermediate hydrogen production Also take into account routes starting from coal.
	Using separate Hydrogen input	Hydrogen (different routes)	May become relevant with large sources of green hydrogen in the future. Can be integrated with Haber-Bosch process.
Nitric acid		Ammonia	
Urea		Ammonia; CO ₂	To be discussed how accounting for CO ₂ sink will work
Ammonium nitrate		Ammonia, nitric acid	

¹¹³ Partial oxidation of heavy refinery fractions or pet coke could also be included here, furthermore gasification of coal has to be assumed as possibility

Material	Production route	Precursors relevant	Remarks
Mixed fertilizers (N, NP, NK)		Ammonia, nitric acid, urea	Various N-containing salts, e.g. ammonium phosphates, ammonium sulphate, potassium nitrate, etc., also act as precursor. For these salts and mixed fertilizers a calculation method is to be developed based on the content of ammonium, nitrate and urea.
Basic aluminium products		Unformed aluminium	To be discussed: Is energy consumption of a separate processing step necessary between liquid aluminium and aluminium products (rolling, extrusion, casting, etc.)? Source of electricity very important
Unformed Aluminium	Primary smelting	Alumina; pre-baked anodes, if applicable	Monitoring of PFC emissions
	Secondary melting (recycling)		Scrap as main input, but assumed to have zero embedded emissions (only if post-consumer scrap).
Alumina			Production from Bauxit. In EU ETS not listed as separate activity / benchmark, as only energy consumption relevant (activity “combustion of fuels”)
Carbon electrodes			Only pre-baked anodes for aluminium production proposed for inclusion

5.6.2 CBAM scope in line with the provisional political agreement

Table 14: Overview of production routes and precursors aligned with the final CBAM Regulation

Material	Production route	Precursors relevant	Indirect emissions covered?
Portland Cement		Cement clinker, Calcined clays	Yes
Cement clinker			

Material	Production route	Precursors relevant	Indirect emissions covered?
Calcined Clays			Yes
Aluminous cement			Yes
Basic steel products		Crude steel	No
Crude steel	BOF route	Pig Iron / Hot metal (from blast furnace or smelting reduction); Alloys ¹¹⁴	No
	EAF routes	Eventually hot metal; DRI (various routes); Alloys	No
DRI / HBI	From natural gas / coal	Sinter / pellets	No
	From H ₂	H ₂ ; Sinter / pellets	No
Hot metal ("Pig Iron")	Blast furnace route	Sinter/pellets; alloys	No
	Smelting reduction	Sinter/pellets	No
Alloys (FeMn, FeCr, FeNi)		Depending on process: Sintered ore ¹¹² ; Silicon or FeSi, Aluminium if relevant	No
Sinter / pellets			Yes
Hydrogen	Steam reforming		No
	Steam reforming with CCS or CCU		No
	Electrolysis		No
	Chlor-Alkali electrolysis		No
Ammonia	Classic Haber-Bosch process (Integrated)		Yes
	Using separate Hydrogen input	Hydrogen (different routes)	Yes
Nitric acid		Ammonia	Yes
Urea		Ammonia; CO ₂	Yes
Ammonium nitrate		Ammonia, nitric acid	Yes
Mixed fertilizers (N, NP, NK)		Ammonia, nitric acid, urea	Yes
Basic aluminium products		Unformed aluminium	No
Unformed Aluminium	Primary smelting		No
	Secondary melting (recycling)		No

¹¹⁴ In this table, "alloys" always means only FeMn, FeCr, FeNi.