

Border Carbon Adjustments in the EU Sectoral Deep Dive



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1 Introduction

The EU institutions have recently adopted the ambitious target of reaching climate neutrality by 2050. This has led to increased interest, and urgency, in examining options to address the risk of carbon leakage and competitiveness as well as measures to address them.

Carbon leakage refers to the situation that may occur if, for reasons of costs related to climate policies, businesses were to transfer production to other countries with laxer emission constraints. This could lead to an increase in their total emissions. The risk of carbon leakage may be higher in certain energy-intensive industries. It must be emphasized that carbon leakage and competitiveness can be seen as two sides of the same coin. At the same time, cost related to climate policies carbon need to also be seen as one component of competitiveness, where other factors also will come into play.

This paper is not intended to focus on the degree to which carbon leakage has occurred or may occur in the future, but on how the design of an adjustment at the border for carbon costs, a border carbon adjustment (BCA), for energy-intensive-trade-exposed (EITE) sectors would be impacted by the different characteristics of the covered sectors: a deep dive in sectoral BCAs.

The European Commission's (EC) action plan, the European Green Deal (EGD), and the goal of net-zero emissions by 2050, with the EU ETS expected - according to senior Commission officials - to reach net-zero possibly as early as 2040, demonstrate the increasing ambition of the EU. On a global scale, these announcements are already highlighting that the asymmetry of climate efforts around the world will continue, with the EU showing a lot more concrete ambition than most of its main trading partners.

The current approach of the EU to levelling the playing field in light of asymmetrical climate change efforts is free allocation of ETS allowances and compensation for indirect costs for those sectors deemed at risk of carbon leakage. The risk addressed by this carbon leakage notion is the transfer of production to third countries with a lower ambition for emissions reduction. Studies show that this approach may not be practical starting towards the end of 2020s, as under different scenarios the available free allocation may start not meeting the needs, with the cross

sectoral correction factor reaching, under certain high demand scenarios, a significant level by 2030¹.

Given the rapidly increasing level of ambition of the EU (which may again increase after the Global Stocktakes under the Paris Agreement), the current significant increase in the EUA prices (from 5 to 40 Euros) and the continued asymmetry in the level of ambition of many of EU's trading partners, it is necessary to explore approaches that can be applied (imperfect as they may be) at different levels of ambition and can ensure that the risks of carbon leakage and competitiveness impacts are addressed effectively.

Applying an adjustment at the border is one approach that has been put forward by the EC under the somewhat generic name of a "Carbon Border Adjustment Mechanism (CBAM)". It is not a new concept, as discussions about a Border Carbon Adjustment (BCA) have taken place, on and off, in the EU and in other jurisdictions. The EC, following political direction, has been preparing a CBAM legislative proposal that is expected by June 2021. The CBAM has become an increasingly important topic on the EU's political agenda.

It must be noted that the discussion about a EU CBAM is focusing on a number of potential objectives. This is directly relevant to the choices made regarding the different options that are available for the components of a CBAM. A CBAM needs to be primarily focused on addressing the risk of carbon leakage and ensuring that there is a level playing field, that is the same cost is associated with each ton of carbon of a product sold in the EU.

In addition, a BCA can be seen as encouraging or nudging other Parties to the Paris Agreement to move to the same level of ambitions as the EU, which needs to be seen in the context of the bottom up and national determined nature of the National Determined Contributions each country makes in the Paris Agreement. Finally, it is also a necessary condition for the EU to be able to speed up its decarbonization process, leading the world in this area.

Against this backdrop, ERCST launched Part I of the project on 'Border Carbon Adjustments in the EU' in November 2019, which concluded in September 2020 with the publication of the report titled "[Border Carbon Adjustments in the EU: Issues and Options](#)". The report offered a detailed analysis of the building blocks of CBAM as a policy option in the European context,

¹ According to BloombergNEF

discussed alternative policy options, and considered different combinations of policy instruments to achieve the desired outcomes.

The present report is the first in a series of four reports that together form the 'Carbon Border Adjustments in the EU - Part II' project launched in November 2020. The four reports include:

1. **Report I: A sectoral assessment** analyzing the suitability of a CBAM in addressing carbon leakage and the competitiveness of individual industrial sectors, as well as its impacts.
2. **Report II: A CBAM proposal** outlining what the ERCST team would see as a combination of the nine BCA dimensions (*identified and assessed during Part I*), informed by the sectoral analysis, providing a balanced and 'best outcome' in their view for a CBAM on its own. It will include all instruments that are part of the EC's Public Consultation document.
3. **Report III: An analysis of the EC's CBAM proposal** after it is put forward, which is expected by June 2021.
4. **Report IV:** A proposal for a framework and pathway for introducing a package of different policy measures to address carbon leakage and competitiveness.

The present report, while it does identify the features of a CBAM that seem most appropriate given the different sectors' characteristics, stops short of recommending an ideal CBAM, or recommending specific flanking policies to accompany it. As noted in the workplan described above, those are tasks for the subsequent reports in this series.

2 Report structure & methodology

2.1 Report structure

The present report provides a 'deep dive' on what a CBAM would mean for individual sectors. It seeks to assess the impacts and suitability of the likely design of the CBAM on individual sectors.

The sectors considered in this report include: cement, chemicals, electricity, ferrous metals, fertilisers, non-ferrous metals, pulp & paper and refined petroleum products.

The report draws on information gathered through consultations with stakeholders and experts, research, data analysis and cooperation with sectoral associations.

Structured interviews with EU sectoral associations, and other stakeholders were conducted in December 2020, as well as follow-up consultations between January and February 2021 to close any remaining gaps. Moreover, feedback by experts in the field from academia and research institutes was provided during a dedicated meeting in early March 2021.

The report is structured as follows:

- First, **sectoral profiles** for the individual sectors are provided (chapter 3). These profiles are structured along five dimensions:
 - *Market structure*, including product types, industrial organisation and investment prospects
 - *Environmental consideration*, including emissions intensity, low-carbon pathways, and resource shuffling
 - *Trade patterns*, including, trade flows, trading arrangements and key trade partners
 - *Other considerations*, including considerations of geopolitical nature
 - *Implications for CBAM design*
- Second, a **cross-cutting analysis** of the sectoral profiles was carried out, outlining a number of overarching patterns across sectors that have relevance for the design of a CBAM, as well as the particularities that are unique to individual sectors (chapter 4).
- Third, the final chapter provides **concluding remarks** (chapter 5)

2.2 Methodology

This section provides a starting framework² for analysis followed in the subsequent chapters, surveying the way various sectoral characteristics are linked to CBAM design choices. While the linkages surveyed here are valid at a general level, they may have different implications in the context of the specific sectors examined, owing to the totality of each sector's unique features, and the interplay with other sectors.

Market structure and dynamics

Sectors with long and complex downstream value chains, containing products of which the upstream GHG-intensive goods constitute a significant part of the value, argue for a broader sectoral coverage, extending down the value chain from basic commodities to cover those processed goods that are at risk of leakage. They may also argue for a scope that includes the emissions embodied in GHG-intensive intermediate goods, and in electricity.

Sectors with close substitutes argue for coverage of either both competing sectors, or neither, to avoid incentives for basic material substitution – a dynamic that may or may not have climate benefits.

Sectors that have the most pressing needs for major capital investments for decarbonization in the near term are the least suitable candidates to be excluded from a pilot phase for CBAM. They need certainty in which to ground their major investment decisions. Uncertainty might lead either to investment being made in foreign facilities, to deferred investments, or to EU investments that lock in carbon-intensive capital stock.

Environmental considerations

Sectors whose trading partners have lower emissions intensity than EU producers will lose competitiveness vis-a-vis those competitors if the CBAM allows foreign producers to challenge any default value for GHG-intensity, and may be at risk of leakage and competitiveness impacts from resource shuffling.

Sectors with large spreads between clean and dirty plants within the EU, however, are probably at risk of seeing those dirty plants close as a direct result of carbon pricing. The risk of resource

² This framework was developed in Andrei Marcu, Michael Mehling and Aaron Cosbey, (2020). "Border Carbon Adjustments in the EU: Issues and Options." Brussels: ERCST.

shuffling and competitiveness impacts noted above is not entirely an issue of CBAM design, so the argument against allowing challenges of the defaults is not as strong.

Sectors with large amounts of indirect emissions attributable to electricity will not be well protected by a CBAM that does not cover both direct and indirect emissions (unless the current system of compensation for indirect costs under the ETS is maintained). Even a CBAM that covers indirect emissions may not actually cover indirect carbon costs: costs created by electricity tariffs that don't reflect actual GHG-intensity.

Sectors with low-carbon pathways that have high cost implications may be in need of instruments to complement a CBAM, such as contracts for difference. Otherwise the protection offered by a CBAM will be insufficient to motivate new investment in such technologies.

Trade patterns

If a CBAM were to replace the existing regimes for free allocation and indirect cost compensation, those sectors with a significant share of exports as a share of total production would need the CBAM (or some other instruments) to somehow protect competitiveness in foreign markets.

Some sectors have trade patterns that involve specific hubs in countries with poor reputations for governance. Allowing country-based exemptions to CBAM coverage would run the risk that goods in those sectors would be illegally trans-shipped through those hubs to benefit from the exemptions. A CBAM that covered such sectors and allowed country-based exemptions would need strong provisions guarding against trans-shipment.

3 Sectoral profiles

3.1 Cement

Sector Profile				
Annual Production (cement)³ 2019		Covered Installations⁴		Plants in Value Chain
EU	185 Mt	Global	4100 Mt	280
Complexity of Value Chain ⁵		Low	Level of Integration	
			High	
Trade Patterns ⁶				
Relative Weight of Imports and Exports (cement, by value)				
Imports as a Share of Domestic Consumption (%)		2,6%	Exports as a Share of Domestic Production (%)	
			7%	
Main Sources of Imports (% of total imports, by value)				
Turkey (34%)	Colombia (8%)	Ukraine (7%)	Belarus (7%)	Bosnia-H. (4%)
				
Summary				
Production of cement clinker is highly energy intensive. While cement has not been as exposed to international trade as other basic materials, this situation is changing as imports to the EU significantly increase. The sector is highly integrated, and the value chain is relatively less complex. Currently, the EU exports more cement than it imports, although that pattern is set to reverse. Also,				

³ EU Data for PRODCOM 2351 (cement) for 2019 from Eurostat, ‘Sold Production, Exports and Imports by PRODCOM list (NACE Rev. 2)’ <<https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do>> (accessed 6 February 2021); global data based on International Energy Agency, ‘Global cement production, 2010-2019’ <<https://www.iea.org/data-and-statistics/charts/global-cement-production-2010-2019>> (accessed 6 February 2021).

⁴ Based on European Commission, ‘Compliance Data for 2019. ETS Union Registry’ (2019) <https://ec.europa.eu/clima/sites/default/files/ets/registry/docs/compliance_2019_code_en.xlsx> (accessed 12 March 2021), counting production of cement in rotary furnaces and production of cement clinker, but not including production of lime, calcination of limestone or combustion installations with a thermal rating of 20 MW or more.

⁵ Here and in the following sector profiles, “Complexity of Value Chain” and “Level of Integration” are not based on a uniform set of quantified criteria, which would not be suited to the substantial heterogeneity across sectors. It is, instead, meant as a heuristic value based on communications with representatives of the sectors and the available literature.

⁶ Data of 2019, based on Eurostat Data for PRODCOM 2351 (cement), supra note 3.

trade volumes are significantly higher in a number of EU Member States: cement imports are concentrated in the eastern, south-eastern and southern borders of the EU as well as large seaports. European producers have reduced their carbon intensity below the global average by firing low-carbon fuels, although process emissions from the calcination of lime – which contribute more than half of emissions from the sector – are more difficult to address, and will necessitate breakthrough technologies such as carbon capture and storage or sequestration.

3.1.1 Market Structure

Cement denotes a variety of substances that serve as a binding agent for different aggregates, yielding concrete, mortar, grout and other construction materials. Its main component is lime resulting from the calcination of limestone, and – depending on the type of cement – chemical reactions with other constituents of the raw materials to form an intermediary product, clinker. Among relevant economic activities, “manufacture of cement” (NACE Code 23.51) is deemed at risk of leakage under the EU ETS,⁷ and covers the production of clinker (HS Code 25231000) and several types of cement, which differ in terms of the clinker content and the share of other components.⁸ A related activity is the “manufacture of lime and plaster” (NACE Code 23.52), which covers the production of several types of lime⁹ and is also deemed to be at risk of leakage.¹⁰ Because of the relative importance for CBAM, this sector profile focuses on cement.

There are different types of cement (for instance five types of Portland cement), each of which has different clinker content and therefore embodied greenhouse gas emissions. All cements must be certified as a specific type to enter into commerce in Europe. This makes it relatively straightforward to determine the direct (process) emissions associated with any given batch,

⁷ European Commission, 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, OJ 2019 L120/2 <<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019D0708>> (accessed 6 February 2021).

⁸ These include, notably, Portland cement (HS Code 25232100 for white Portland cement and 25232900 for other – including “grey” - Portland cement) and other hydraulic cements, including aluminous cement (HS Code 25233000). European cement standard EN 197-1 defines 27 distinct common cement products and their constituents, and sets out performance requirements for strength and volume stability.

⁹ These include quicklime (HS Code 25221000), slaked lime (HS Code 25222000) and hydraulic lime (HS Code 25223000).

¹⁰ European Commission, Commission Delegated Decision (EU) 2019/708, supra note 4.

particularly since direct emission intensity for cement is more or less uniform across different installations. Cement has few substitutes in existing construction applications, although alternative construction methods can use timber, steel, and glass for applications that display different characteristics. Downstream products include concrete products used for construction purposes, ready-mixed concrete (HS Code 38245010), mortars (HS Code 38245090), fibre cement, and various articles of concrete, plaster and cement, such as building blocks, bricks, flagstones, tiles, panels, and prefabricated structural components of buildings.

In the European Union, the cement sector is dominated by a small number of large producers distributed across various Member States. Several of the larger producers are multinational corporations, although private ownership predominates: only the four largest producers are owned by shareholders. It is a mature sector, with clinker and cement production highly integrated from quarry to clinker grinding and blending, although the downstream production of concrete and other cement-based products is largely carried out by smaller local companies. Cement is almost exclusively traded between businesses (B2B), with the main consumers being ready-mixed concrete producers, pre-fab element producers, construction companies, and, to a much lesser degree, DIY markets. Trading primarily occurs directly from producers to these consumers, although international trading can occur via trading companies. Often, smaller companies with storage silos near trading ports will import clinker and operate nearby grinding mills to convert the clinker into cement.

3.1.2 Environmental Considerations

In Europe, the environmental performance of cement manufacturing is relatively homogenous, given that about 60% of emissions stem from the calcination process that converts limestone to quicklime. Differences within Europe primarily arise from the fuels used to generate heat in the cement kilns, with some plants – primarily in the north and northwest of Europe – firing partly biomass waste rather than the more widely used and carbon-intensive traditional fossil based fuels. Other substitutes for fossil fuels include fractions from municipal waste, sewage sludge or tires. Concrete can be 100% recycled, although the recycling quota is still fairly low across Europe with some high outliers (e.g. Netherlands). Also, atmospheric carbonation of concrete results in continued absorption of CO₂ over time.

Because of the high share of process emissions in overall emissions, however, alternative heating technologies – based, for instance, on electricity or hydrogen – can only contribute to partial decarbonization, as only the emissions caused by the combustion process (30% of overall CO₂ emissions) are reduced. European production has already largely shifted from wet to less energy-intensive dry production methods. Carbon capture and sequestration will therefore be

an essential element in any pathway towards full decarbonization of the cement sector, alongside the development of alternative cements not based on clinker.

Indirect costs from electricity consumption make up a sizeable share of overall production costs, with high volumes of electricity needed to operate motors in the operation of the kilns and other parts of the production facilities, such as grinding equipment, conveyor belts and ventilators.

In sum, Europe's cement production is generally lower in GHG emissions than most global production. While the process emissions are more or less the same worldwide, EU producers use a relatively higher share of lower-carbon fuels: waste materials, natural gas and, in some cases, biomass.

3.1.3 Trade Patterns

Clinker and cement are imported into the European Union, with the main channels situated alongside the southern, southeast and eastern borders and coastal areas (notably the Netherlands and Belgium). Relevant trade partners include Morocco in the south, Turkey in the southeast, and Russia, Belarus and Ukraine in the east. These countries are significantly increasing their production capacity. An increasing amount of clinker and cement is also arriving from other countries at the large European ports in Rotterdam, Ghent, Antwerp and Marseille.

Overall, the trade balance of the European cement sector is currently positive (whereas it was largely negative before 2009), with exports exceeding imports, although the trend is reversing fast. Typically, imports progressed rapidly since 2016 (+130% in volume, +80% in value), while exports decreased significantly over the same period.¹¹ While other factors than carbon prices have likely contributed to this rise in imports, there is significant potential for leakage in the cement sector in the face of increasing carbon prices in the EU, mostly concentrated on coastal markets, given the high cost of inland transport.

3.1.4 Other considerations

The vast majority of cement imported into the EU – more than one third – comes from a single country, Turkey. A CBAM that includes cement will therefore have a noticeable impact on the Turkish cement industry, and this may negatively affect the already complicated diplomatic relationship between Turkey and the EU. Following, with a sizeable margin, are Colombia and several Eastern and Southeast European countries. Unlike in some other sectors, however, the high cost of transporting cement relative to its value limit the number of overseas trade partners

¹¹ Based on Eurostat Data for PRODCOM 2351 (cement), supra note 3.

that would be meaningfully affected, including political heavyweights such as the United States, India or China. Also, while the main trading partners – except Colombia – have yet to introduce a carbon price, recent political developments (including, for instance, under the Eastern Partnership process) suggest an openness to consider carbon pricing policies and potentially gradual policy convergence.

3.1.5 Implications for CBAM Design

The sector sees itself as a potential candidate for coverage under a CBAM, but has indicated that it considers a CBAM a complement, and not a substitute, to already existing carbon leakage safeguards, notably the free allocation of allowances. Cement has few differentiated downstream products subject to leakage, so would be well covered by a CBAM with narrow sectoral scope – one that covered only basic materials. It does, however, have an important upstream input – clinker – that is highly emissions-intensive and trade-exposed, and would need some form of coverage. Cement competes with steel as a building product to some extent and in some applications, as it also relies on steel as a reinforcement material in construction. Arguably, therefore, if one of the two – cement or steel – were covered under a CBAM, the other should also be covered, to avoid material substitution dynamics.

Investment in cement production has extremely high upfront costs, and long plant life. The 2030 and 2050 timelines for ambition mean that several plants per year must be modernized at costs exceeding EUR 100M each, but that investment cannot happen without certainty of protection from leakage. As such, cement is a potential candidate for early inclusion in a CBAM regime.

Indirect emissions are the minority of cement sector emissions, but they are what distinguishes low-carbon from high-carbon production. Ideally, they would need to be covered in the adjustment. There is some potential for resource shuffling in cement, mostly on coastal markets, that would argue against allowing foreign producers to challenge any default values for embodied carbon. Finally, exports currently exceed imports, and are less than 10% of domestic production but with some higher values in certain countries for which export coverage under CBAM would be important.

3.2 Chemicals

Sector Profile					
Annual Production, basic chemicals¹² 2019 (value, million €)			Covered Installations (bulk chemicals)¹³		Plants in Value Chain¹⁴
EU 27	230.787	Global	n/a	350	>10,000
Complexity of Value Chain			High	Level of Integration	Medium
Trade Patterns (plastics in primary forms) ¹⁵					
Relative Weight of Imports and Exports					
Imports as a Share of Domestic Consumption (%)		38,1%		Exports as a Share of Domestic Production (%)	33,6%
Main Sources of Primary Plastics Imports (% of total imports, by value)					
US (21,2%) 	UK (14,3%) 	Korea (12.1%) 	Saudi Arabia (9,2%) 	China (6,7%) 	
Summary					
<p>The chemicals sector is in fact an array of different sectors. Here we focus mostly on organic basic chemicals and the downstream primary plastics that they can produce, those being the sectors with the most significant GHG emissions and volumes. Even within that focus, the spread of activities is considerable, with multiple basic chemicals, a widening array of intermediate chemicals, and countless final consumer products. Most emissions are indirect, the result of the need for large amounts of process heat. The sector has a significant export component and faces significant pressure from foreign competitors.</p>					

¹² Production data are for all NACE class 20.1: Manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber in primary forms (apart from code 20.15 – fertilizers). 2019 data.

¹³ EU. 2019. Compliance data for 2019. ETS Union Registry. Accessed at https://ec.europa.eu/clima/sites/default/files/ets/registry/docs/compliance_2019_code_en.xlsx

¹⁴ Communication from European Chemical Industry Council (CEFIC).

¹⁵ Eurostat. By value, 2019 Euros. Data is only for sector: 20.16 (plastics in primary forms).

3.2.1 Market structure

The chemicals “sector” is in fact many related sectors. Five chemicals product categories are covered under the existing EU ETS:

- Manufacture of industrial gases (NACE 20.11) ;
- Manufacture of other inorganic basic chemicals (NACE 20.13);
- Manufacture of other organic basic chemicals (NACE 20.14);
- Manufacture of fertilizers and nitrogen compounds (NACE 20.15); and
- Manufacture of plastics in primary forms (NACE 20.16).

Three more sub-sectors are listed as vulnerable under the EU’s ETS phase 4 leakage list, and therefore will be covered in the next phase:¹⁶

- Manufacture of dyes and pigments (NACE 20.12)
- Manufacture of synthetic rubber in primary forms (20.17); and
- Manufacture of man-made fibres (20.60).

We will consider fertilizers apart from the rest as a separate sectoral write up. Gases includes hydrogen, and inorganics includes soda ash and carbon black, all of which are significant. But our attention here will focus on organic chemicals and their downstream products – plastics. These are the most significant in terms of production values (84.4% of non-fertilizer chemicals in 2019), traded values and GHG emissions.

Organic chemicals comprise an array of compounds that numbers nearly 20 million, but the most commercially important and emissions-intense of them are petrochemicals. In the EU, crude oil is the predominant petrochemical feedstock, but natural gas is used elsewhere, such as in the US which benefits from low-cost shale gas.

Hydrocarbons are distilled (or cracked) from feedstock in a highly energy-intense process to produce such basic chemical products as ethylene, benzene, propylene and toluene. Of these

¹⁶ EC. 2019. “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.” *Official Journal of the European Union*, L120/20-26, 8.5.2019.

the most significant by volume is ethylene, which is used in the production of polyethylene (PET, the most widely used plastic), polyvinyl chloride (PVC, used in construction, consumer goods), and a wide variety of other compounds used in final goods and industrial processes. Polymerized propylene (polypropylene) is the second most widely used plastic.

The final stages of the organic chemicals/plastics value chain are numerous and widely varied, comprising for example: food and other packaging, detergents, agrochemicals, coatings, adhesives, inks, detergents, pharmaceuticals, automotive components, electrical products, construction materials, tires and synthetic rubber, carpet backing, paper coating, belts, flooring, insulation, footwear, solvents, plastic bags, plastic films, plastic bottles, household appliances, furniture, and synthetic fibres. 56% of chemicals production is used as input goods in non-chemicals sectors.¹⁷ At the level of these final goods, the dynamics of leakage and competitiveness are different, not as acute. Products are differentiated on bases other than just cost, and carbon costs as a percentage of value are much lower than in the upstream.

Organic chemicals accounted for 55,2% of non-fertilizer chemicals sector sales in 2019. But that understates their significance, since they are used in downstream sectors such as plastics, which accounted for another 29,2% of sales, and in some consumer chemicals and specialty chemicals.

EU production is not as vertically integrated as in other countries, characterized by some very large basic chemicals producers, with over €1 billion turnover – the energy-intensive petrochemical producers – and many smaller downstream users of basic chemicals, specialized mid-sized producers that number over 10.000 firms.

3.2.2 Environmental considerations

The chemicals industry as a whole in the EU (EU-27 excl. Norway excl. UK, incl. pharma) has reduced its absolute emissions over 1990 levels by 58%, with GHG intensity (per unit of production) falling 76% over that period.¹⁸ But is still a major emitting sector, with 146 Mt CO₂e in 2017.¹⁹ Almost all of that is emitted as CO₂, with the majority emitted from fuel used in the process of producing basic chemicals. As such, most of their emissions are direct, but chemical producers still use significant amounts of electricity. Purchased electricity is not eligible for free allocation, and some on-site combined heat and electricity is accounted for as electricity production only, rather than chemical production emission, and therefore also not eligible.

¹⁷ CEFIC. 2020. “2020 Facts and Figure of the European Chemical Industry.”

¹⁸ Ibid.

¹⁹ Ibid.

Electro-intensive production processes qualified for indirect compensation (subject to member states' choice). However, petrochemicals (NACE 20.14) were recently taken off the sectors' list eligible for indirect compensation for phase IV.

EU production of chemicals is clustered in industrial hubs that create synergies of energy and feedstock flows, with many integrated operations. These arrangements yield enormous efficiency at levels not found in many other countries. The overall effect is that EU producers are more efficient and therefore less GHG-intense than many of their competitors. Similar clustering and integration is taking place on the East coast of China, where existing capacity will be augmented by four major integrated petrochemical plants coming on stream in the next few years. The Middle East has also been building up modern integrated production capacity, using cheap ethane feedstock. Both represent relatively low-cost and low-carbon competition for the EU.

Decarbonization in the chemicals sector will involve research, development and deployment in a number of streams, including process innovations like the use of catalysts to reduce process energy consumption, carbon capture and storage/use, and innovative processes such as methane-to-olefins, which have lower energy demands.²⁰ Another avenue—recycling of chemicals and plastics—is a more mature field, and holds significant potential.

3.2.3 Trade patterns

The EU enjoys a trade surplus in non-fertilizer chemicals, in 2019 exporting €82,7 billion and importing €61.7 billion.²¹ Primary export destinations were the US, Turkey and the Middle East. Primary import sources were China, Switzerland and Japan.

Though it accounts for a major portion of total sales, very low volumes of ethylene (or other monomers) are traded internationally – less than 3% of total production in 2019. Rather, the downstream derivatives, such as PET and other polymers, are traded. Petrochemicals and polymers together accounted for 43% of exports, with high-value specialty chemicals accounting for another 34%.

The EU chemicals sector has experienced a secular decline in global market share over the last 20 years, falling from 33% in 1998 to 17% in 2018, though the growth of the global market has

²⁰ ICF/Fraunhofer ISI. 2019. Industrial Innovation | Part 1: Technology Analysis.

²¹ Trade data is based on Eurostat databases, 2019. Includes NACE codes 20.11, 20.12, 20.13, 20.14, 20.16.

meant modest absolute gains: a compound annual growth rate of 2,3%.²² Much of that global market share has gone to China, which achieved an increase from 18,2% to 35,8% over the same period.²³

3.2.4 Other considerations

The US is the EU's top source of imports of both plastics and organic basic chemicals, at 21,2% and 14,6%, respectively, of total imports. On the strength of significant export flows like those in the chemicals sector, the EU can expect to field pressure from the new climate ambitious US administration to somehow credit its climate ambition, though this will be difficult absent a US carbon price. The US producers' use of fracked natural gas as a feedstock gives some indication of the pressures that will be brought to bear on the methodologies for determining actual emissions intensity, should the EU choose to allow foreign producers to challenge a default value for emissions intensity of imports. China is the next most significant source of imports of organic basic chemicals, at 14,5%. With petrochemical production capacity due to increase significantly in the coming few years, China can be expected to be concerned not only about existing trade flows, but also about future expected flows (though its new integrated plants will be highly efficient). The UK is the EU's second largest source of plastics imports at 14,3%, and the former EU member state will be looking for special status under the CBAM to protect trade flows in sectors like this.

3.2.5 Implications for CBAM design

There is clearly a need for protection in the chemicals sector from the risk of leakage and competitiveness impacts. The global market for downstream products is competitive, and the EU faces strong pressure from countries with efficient producers without equivalent climate costs, at least for the foreseeable future.

Chemicals offer a challenge on the question of sectoral scope: how far down the value chain should BCA extend? The most significant emissions by far in the chemicals sector (excluding fertilizers) occur in the production of basic chemicals – monomers like ethylene. These would be protected by a BCA applied upstream, though these products are not heavily traded. Trade comes also downstream, with polymers like polyethylene and polypropylene and the various products derived from them. We can probably assume that the sectoral scope of a CBAM would

²² CEFIC, 2020 (supra).

²³ CEFIC, 2020 (supra).

extend down to the level of polymers, in line with the free allocation coverage provide by the EU ETS.

Two problems emerge: first, while upstream producers of basic chemicals and polymers may be covered by a CBAM, the value chain downstream from them is extensive, involving a wide array of manufactured products outside the chemicals sector. None of these would be sheltered by an upstream CBAM, though they would face increased costs of inputs from both domestic and international suppliers. These manufacturing firms, if not also covered by BCA, face the potential of leakage and competitiveness impacts. Yet extending BCA to the level of manufactured goods is widely regarded as administratively challenging.

Second, the processors of basic chemicals – manufacturers of polymers – would receive BCA coverage only for the carbon costs incurred at that level of the value chain, while significant cost increases would be transmitted down the value chain from producers of basic chemicals where the most GHG-intensive processes take place. This would argue for a scope of emissions coverage that extended to some scope 3 emissions – those embodied in input goods. A BCA that covered only direct emissions of the product itself (without upstream emissions) would miss the lion's share of carbon costs for basic organic chemical production.

This is a sector that exports a significant portion of its total production. In 2019 The EU exported organic basic chemicals and plastics amounting to over 37% of total production. This argues for a CBAM that includes exports in its scope of trade coverage. Absent a CBAM with export coverage, or some instrument to protect the market share of EU chemicals exports in highly competitive global markets, any increase in climate ambition would leave those exporting firms vulnerable to leakage and competitiveness impacts.

The chemicals sector's characteristics also have implications for policies that would run parallel to any CBAM, especially as regards electricity. Electrification of chemical manufacturing processes would provide opportunities to significantly reduce the sector's carbon footprint in Europe. But policies removing tax and tariff exemptions, and the lack of State aid provisions allowing indirect carbon cost compensation for purchased electricity, undermine the sector's ability to invest in electrification.

3.3 Electricity

Sector Profile					
Gross Annual Production (TWh in 2018)		Producers (EU27) in 2018		Capacity (EU27)	
EU27 ²⁴	2.946	10 neighbouring countries ²⁵	1.643 ²⁶	82 main generating companies ²⁷ 3.944 generating companies ²⁸	861 GW (main activity producers) 70 GW (autoproducers)
Complexity of Value Chain		Low		Level of Integration	
				High	
Trade Patterns ²⁹					
Relative Weight of Imports and Exports (electricity, by volume)					
Imports as a Share of Domestic Consumption (%)		3,4% (from all countries of origin) 1,3% (from 10 neighbouring countries)		Exports as a Share of Domestic Production (%)	
				3,3% (to all country destinations) 0,7% (to 10 neighbouring countries)	
Main Source of Imports (% of trade flows) in 2018					
Switzerland ³⁰ (29,6%)	Norway ³¹ (18,3%)	Russia (12,9%)	Ukraine (7,1%)	Bosnia & Herzegovina (6,3%)	Serbia (4%)
					
Turkey (3,2%)	UK (2,3%)	Belarus (2,1%)	N. Macedonia (2%)	Albania (1,1%)	Morocco (0,2%)
					

²⁴ Production in EU27 for 2018 from Eurostat ‘Gross and net production of electricity and derived heat by type of plant and operator’ [nrg_ind_peh] dataset

²⁵ The ten neighbouring countries include: Albania, Belarus, Bosnia and Herzegovina, Montenegro, Morocco, North Macedonia, Russia, Serbia, Turkey and Ukraine.

²⁶ For Belarus, Morocco and Russia data are from 2016

²⁷ Source: Eurostat; main = market coverage above 5% of national generation

²⁸ Generating companies representing at least 95% of national net electricity generation; Figure excludes DE; Source: Eurostat

²⁹ Imports to EU27 for 2018 from Eurostat ‘Imports of electricity and derived heat by partner country’ [nrg_ti_eh] dataset; Exports in EU27 for 2018 from Eurostat ‘Exports of electricity and derived heat by partner country’ [nrg_te_eh] dataset

³⁰ As of 1 January 2020, Switzerland linked its greenhouse gas emissions trading system (SETS) with the EU ETS

³¹ Norway is part of the EU ETS

Summary

Electricity was never the main target for adjustments for carbon at the border. It has now become an increasing topic and the data tells the story. While electricity is not a complex product, it is currently differentiated in many cases by the type of contract and origin of the power, especially when it comes to renewable, non-renewable, and nuclear. As electrification and decarbonization gathers increasing pace this differentiation will increase, and also increase in importance. Electricity is the substitute for many other energy carriers and electrification is meant to rapidly increase.

The share of imported electricity is rapidly increasing in the border areas and it will likely continue to increase as cross-border ties increase and production across the border is ramped up. A significant amount is currently coming from countries that have carbon costs (Switzerland and Norway) but that balance is shifting. Renewable energy in border Member States is competing with electricity from power sources not subject to a carbon cost. This is currently creating tensions as EU Member States strive to drive towards decarbonization and coal phase-out is gathering speed. Coupled with the closure of the coal mining sector in some EU regions it risks creating social tensions as well and needs to be acknowledged and addressed.

3.3.1 Market Structure

Electricity is a homogenous product in terms of its physical characteristics except if we take into consideration the reliability of supply as well as its origin. With regard to the level of reliability, market segmentation exists. Another element that allows for market segmentation is origin, with a clear split around renewable and non-renewable, which differs considerably in their carbon intensity.

The EU has clear requirements in terms of certificates of origin. There are indeed different types of guarantee which specify the origin of that energy source (e.g. generic renewables, wind, hydro, etc.) and the more specific the more expensive is the guarantee. Consumers are thus paying for the guarantees of the electricity. There is further segmentation when it comes to carbon intensity between gas and coal.

The electricity industry is heterogenous. Traditionally it was dominated by state monopolies, but it has been decentralized into a distribution, transmission, generation, with in many cases a transmission system operator (TSO) that plays the role of ensuring a supply/demand balance.

While most companies are publicly traded, it is by no means uniform with the state keeping a large share in some cases (e.g. EdF, ENEL, ENDESA, Orsted, Vatenfal.).

In the former Eastern bloc countries in central and eastern Europe, the state still has a significant amount of ownership, especially given the high carbon intensity of the generation and in some cases weak interconnections.

There are a number of electricity markets in the EU, and it is not helpful to look at it as a single electricity market. While interconnections have been built where there were none not long ago, a number of regional electricity markets can be identified: Scandinavia, Iberia, Western Europe (Germany, Benelux, France), Italy, Western Balkans, Poland, Finland and the Baltic states.

As interconnections are not strong, and transmission lines potentially long, only some of these markets will be on the table for discussion. These will be markets which are on the borders of Europe, with interconnections that will allow for significant amounts of imports from third countries. There are currently plans to increase interconnections with non-EU countries with higher carbon intensity grid up to 31%, with 15% in the Western Balkans (which already have a high carbon intensity generation). All 21 cross border interconnectors serve to connect an EU grid to a higher non-EU intensity grid.

We compared these total connection capacities to the total physical energy flows observed in 2018, to estimate interconnector utilisation for each non-EU country. Sandbag estimates ranged from 5-41%, with an overall utilisation of 13%. Albania had the highest (the only one above 20%), and Belarus the lowest. On this basis we conclude that spare interconnection capacity exists with every presently connected non-EU country.³²

While some power companies are dominant in their respective market or national jurisdictions, competition in markets varies from region to region and from EU member state to member state, depending on presence of multiple power companies as well as strong interconnections within and outside the EU.

At the same time there is a strong push to electrify industry and society in general with demand expected to increase by double by 2050.

According to the European Commission long term strategy the energy investment will have to increase from current 2% of GDP to 2,8% (or around € 520-575 billion annually) in order to

³² Sandbag (2020), How electricity generated from coal is leaking into the EU

achieve a net-zero greenhouse gas economy. Electrification of some segments of the economy already makes the process more efficient.

Electricity sector at the moment is regarded as a substitute for other fuels. In connection with the renewable sources, it needs backup in order to benefit from flexibility, and requires storage capacity through batteries and especially hydro power. Generally, gasoline could be a substitute in the transport sector. Electricity is important for the heating sector. It is competing with fossil fuels as well as cogeneration and district heating networks, especially in Eastern Europe.

3.3.2 Environmental considerations in the EU

The carbon intensity in the EU can vary considerably between EU Member States. However, the most important ones are related to those areas on the EU borders whose carbon intensity becomes relevant in relation to those outside the EU and which could provide opportunities for importing power in the EU.

Against an EU average in 2018 of 287(gCO₂/kWh), some EU Member States on the border of the EU have relatively high carbon intensity: in Estonia (900), Greece (662), Poland (789). Other countries such as Finland (111), Romania (291), Spain (276), Hungary (251) have relatively low-to-average carbon intensity³³. What many have in common is interconnection ties with countries outside the EU and in some case ambitious decarbonization plans in the power sector which in the context of the EGD should be replaced by renewable energy. These include Spain (phase out by 2030), Greece (phase out in 2028), Croatia (high ambition on RE), Hungary (will decarbonize extensively by 2030).

In terms of low carbon pathways, Eurelectric, the European association of power companies has put forward its vision to playing a key role to enable and sustain a climate neutral European economy with net-zero greenhouse gas emissions by 2050, reliably powered by affordable energy from renewable and carbon-neutral sources.

According to Eurelectric, cost-effective pathways to 2045 will depend on four key elements: a) electricity supply with over 80% from renewables; b) diversification of power sources to ensure system reliability and flexibility; c) changing role of conventional generation, which will provide

³³ European Environment Agency (2020), Greenhouse gas emission intensity of electricity generation, https://www.eea.europa.eu/data-and-maps/daviz/co2-emission-intensity-6#tab-googlechartid_googlechartid_googlechartid_googlechartid_chart_11111

back-up energy while gradually being less used for energy production; d) maturity of CO₂ offset (e.g. CCS) and power-to-gas technologies.

Higher investment levels in renewables and infrastructures are required to reach full decarbonisation while simultaneously meeting higher power demand stemming from increased electrification. Annual average investments of 89-111 billion euros will be required to decarbonise the power sector and other segments of the EU economy such as transport, building and industry. Investments will also be needed to strengthen electricity network interconnections across Europe and reinforce distribution grids.

3.3.3 Trade Patterns

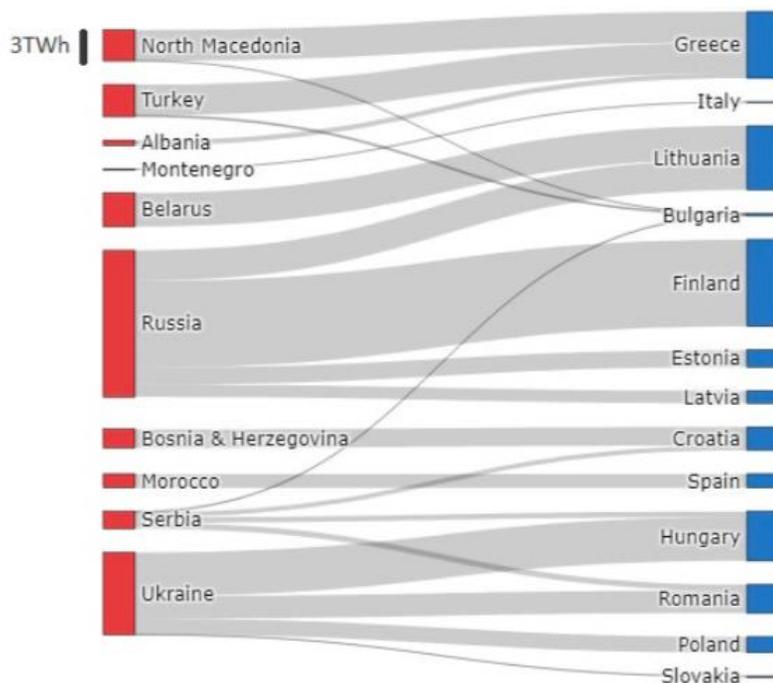
Traditionally sectors such as the power sector may not appear to be exposed to carbon leakage based on the ratio of EU imports to EU production. This concern was reserved by-an-large to EITE industries. However, changing circumstances and a deeper analysis will reveal that it may be a concern on a local level, if one looks at specific border regions of the EU.

The EU27 was a net importer of electricity in 2018 (of about 3 TWh) and a net exporter in 2019 (of about 6,2 TWh) when all countries of origin and destination are considered, i.e. including trade flows with non-EU countries participating in the EU ETS. However, when considering trade flows with the EU's ten neighbouring countries that are not participating in the EU ETS (i.e. Albania, Belarus, Bosnia and Herzegovina, Morocco, North Macedonia, Russia, Serbia, Turkey and Ukraine), there have been increasing net imports of electricity into the EU, from 3 TWh in 2017 to 21TWh in 2019.

This is encouraged by a number of developments. All imports are coming from countries that have basically zero carbon pricing associated with them. The first figure shows the trade flows between EU ETS imports while the second shows the electricity exchanges between EU and neighbouring countries in 2019 (both taken from the Sandbag report). The last one shows the annual electricity trade and associated carbon emissions (also Sandbag). It is quite clear that imports at 33TWh are higher than exports at 12,6 TWh and rapidly growing. They are also concentrated imports originating from 3 regions (Russia, Ukraine and W Balkans) while the

importers being concentrated in 4 EU countries (Finland, Lithuania, Greece and Hungary). Spain is also receiving imports from Morocco³⁴.

EU ETS gross electricity imports (TWh) in 2019



Gross imports into EU ETS countries in 2019, by origin (left) and destination (right). The thickness of lines is proportional to the volume of electricity in TWh. Note: Imports from Russia to Lithuania all originate from the Kaliningrad enclave.

Source: Sandbag (2020), figure 2, page 6

³⁴ From 2018 to 2019, net imports to Spain increased by 4.2TWh from -3.4TWh to 0.8TWh. Sandbag, Jan 2020.

Electricity exchange between the EU and neighbouring countries



Gross (bars) and net (grey points) electricity flows in and out of the EU ETS region through all interconnectors.

Source: Sandbag (2020), figure 1, page 6

Annual electricity trade, and associated carbon emissions, between countries in the EU ETS and connected neighbours.

	Year	2015	2016	2017	2018	2019
Electricity (TWh)	Import	26.8	29.0	25.9	36.1	33.3
	Export	23.8	20.8	22.8	16.8	12.6
	Net	3.0	8.2	3.1	19.2	20.7
Carbon (MtCO ₂)	Import	21.5	23.2	20.3	29.2	25.6
	Export	12.0	10.2	10.9	8.5	6.0
	Net	9.5	13.0	9.4	20.7	19.6

Source: Sandbag (2020), table 1, page 8

What is also important is the fact that while there have been imports electricity this are only bound to increase given the increase in interconnection capacity and the increase in power plant construction in the areas that are adjacent to the EU borders, and that will be used for exports.³⁵

In terms of new coal fired capacity, 57 GW of new coal capacity is being built with some of the largest developers being Serbia, Bosnia & Herzegovina and Turkey.³⁶ By 2030 the interconnection capacity is expected to increase by 31%. In most cases this involves non-EU countries with a higher GHG grid emission factor.

Since electrons are indistinguishable, it is the contracted energy or capacity with possible specificity for specific power units. However, existing capacity is mostly coal-fired, as is planned additions. Planned solar exports from outside the EU will be easy to be compensated shifting coal fired generation for internal uses, depending on contracts and dispatch order.

3.3.4 Other considerations

Looking at imports from countries without links to the EU ETS, the majority of electricity imports to the EU (circa 14% of total imports) originate from Russia (to Finland and the Baltic States). Due to historical and geographical reasons, the power systems of Estonia, Latvia and Lithuania are strongly connected to and operate in parallel with the power systems of Russia and Belarus. Traditionally the energy sectors in the Baltics have been vulnerable due to this inextricable link to Russia while at the same time being isolated from the rest of the EU. The situation has been evolving, as the Baltic States have agreed to connect their power grids to the EU by 2025 and break their dependence on Russia. The power systems of the Baltic States still lack adequate electricity connections between themselves and to other parts of the EU. However, in the last years additional connections between Estonia and Finland, between Lithuania and Poland and between Sweden and Lithuania have been built, which have raised the transfer capacity between the Baltic and the EU electricity markets, and with it also decreased dependence on Russia³⁷. Additional planned or proposed interconnections will further decrease vulnerability, such as a new high-voltage direct current cable between Lithuania and Poland to run under the

³⁵ There are several further planned interconnections between e.g. Morocco and Portugal, Tunisia and Italy, Libya & Egypt and Greece, Bosnia & Herzegovina and Croatia, Turkey and Romania, etc.

³⁶ Sandbag (2020), How electricity generated from coal is leaking into the EU

³⁷ Joint Research Centre (2016), *The Baltic Power System between East and West Interconnections*, p.2

Baltic Sea, looping around the territorial waters of Russia's Kaliningrad exclave, or a proposed project to connect Sweden to Latvia via the Island of Gotland.

The countries that would be affected by a CBAM are a mixture, with the Russian Federation a member of the G20 but one that the EU is trying to maintain a dialogue while lessening its energy dependence. Other countries are countries in the neighbourhood and important, as these relations are important to the EU for trade and other reasons. At the same time, the EU is encouraging them to decarbonize through agreements and assistance.

3.3.5 Implications for CBAM design

Electric power was always considered to be a local industry with little exposure to leakage. Circumstances change and with deregulation, more focus on efficiency, new generation and transmission technologies, and the importance of sourcing low carbon generation, we may likely see an increase in energy imports and the risk of damage done to those that take the lead and decarbonize and expose the new low carbon generation to competition from, in many cases, carbon unregulated power facilities outside the EU.

While electricity exports play an important role, they are overshadowed by imports, and that can only increase as the interconnection capacity and available generation capacity outside the EU increases. While some jurisdictions are looking to put a price on carbon, that is not likely to happen early in this EU ETS trading period.

This is not a sector that is complex downstream, as electricity is sold B-B to other power companies, TSOs and depending on legislation, potentially to industrial consumers. As such, the power industry would militate on a simple cover of electricity imports. The origin of the power and its carbon content are an issue that needs to be solved as electrons are not distinguishable, unless units are separated on the importing system.

With electrification playing an increasing role in decarbonization, it is unlikely that other sources of energy will be substituted for electricity. Electrification is at the heart of EU's decarbonization drive, both for energy and industrial purposes, to the extent possible.

What is important to note is the fact that there will be huge increases in the power generation capacity due to the need for increased decarbonized capacity and also for the replacement of coal-fired plant closures. This will require huge investments, in many cases in countries that are currently experiencing increasing imports and are building new interconnections outside the EU. As such, electricity could be considered as one of the candidates that should be included in a "first wave" of CBAM covered sectors - it is less global and fairly homogenous. In addition, electricity does not benefit from free allocation (with some possible exceptions), so this will likely eliminate any reluctance from the power industry.

3.4 Ferrous Metals

Sector Profile					
Annual Production (crude steel)³⁸ 2019			Covered Installations³⁹		Plants in Value Chain
EU	157,5 Mt	Global	1870 Mt	511	~500
Complexity of Value Chain			Medium	Level of Integration	
				Medium	
Trade Patterns ⁴⁰					
Relative Importance of Imports and Exports (basic iron and steel, by value)					
Imports as a Share of Domestic Consumption (%)		19,7%		Exports as a Share of Domestic Production (%)	
				15,6%	
Main Sources of Imports (% of total imports, by value)					
Russia (15%)	Turkey (11%)	Ukraine (10%)	China (8%)	S. Korea (8%)	
					
Summary					
<p>Production of ferrous metals is a carbon-intensive activity with high trade exposure. Both imports to and exports from the EU are significant, with continued growth of imports resulting in a negative trade balance. Trade is global, with the main EU trade partners including several major economies. It is dominated by a number of semi-finished and finished steel products. EU production is already less carbon-intensive than that of many trade partners, but further decarbonization in this capital-intensive sector will depend on support for breakthrough technologies. Secondary production of steel relies on electric arc furnace technology, resulting in high indirect emissions and indirect carbon costs. Global overcapacity increases the risk of cost absorption and resource shuffling, but trade conflicts have marginally improved data availability for foreign producers.</p>					

³⁸ Data from EUROFER, 'European Steel in Figures 2020' (Brussels: EUROFER, 2020) <<https://www.eurofer.eu/assets/Uploads/European-Steel-in-Figures-2020.pdf>> (accessed 6 February 2021).

³⁹ Based on European Commission, 'Compliance Data for 2019. ETS Union Registry' (2019) <https://ec.europa.eu/clima/sites/default/files/ets/registry/docs/compliance_2019_code_en.xlsx> (accessed 12 March 2021), counting coke ovens, production of coke, production of pig iron or steel, production or processing of ferrous metals, and production of pig iron and steel in continuous casting installations, but not including combustion installations with a thermal rating of 20 MW or more.

⁴⁰ Data for PRODCOM 2410 (basic iron and steel and ferro-alloys) for 2019 from Eurostat, 'Sold Production, Exports and Imports by PRODCOM list (NACE Rev. 2)' <<https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do>> (accessed 6 February 2021).

3.4.1 Market Structure

Ferrous metals include iron, steel, and alloys thereof. The value chain of ferrous metals includes all the processes required to transform the raw materials into finished iron and steel products, and includes coke ovens, sinter and pellet plants, blast furnaces, steel furnaces and rolling and finishing mills. Of these, the activities deemed to be at risk of carbon leakage under the EU ETS are: ore mining of hard coal (NACE Code 05.10) and iron ores (NACE Code 07.10), manufacture of coke oven products (NACE Code 19.10), sinter and pellet plants as well as blast and steel furnaces for manufacture of basic iron and steel and of ferro-alloys (NACE Code 24.10), manufacture of tubes, pipes, hollow profiles and related fittings, of steel (NACE Code 24.20) and cold drawing of bars (NACE Code 24.31).⁴¹

In terms of production volumes and trade intensity, the ferrous metals sector is dominated by steel, which the following sector profile will therefore focus on. Steel is an alloy of iron with small amounts of additional elements – mostly carbon – as hardening agents. Steelmaking and related activities carried out on site, such as sintering and coking of coal, are registered under NACE Class 24.10.⁴² Production of crude steel mainly occurs through two processes: primary production from iron ore via production of hot metal in a blast furnace (BF) and subsequent conversion to crude steel in a basic oxygen furnace (BOF);⁴³ and secondary production, produced by the smelting of scrap or direct reduced iron in an electric arc furnace (EAF). Both routes differ in the metallurgical process, energy input, and process emissions, as well as in the quality and uses of the resulting steel.⁴⁴ In 2019, 59% of crude steel produced in the EU originated from

⁴¹ European Commission, 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, OJ 2019 L120/2 <<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019D0708>> (accessed 6 February 2021).

⁴² Under the EU ETS, iron and steel production is divided into production of coke, metal ore roasting or sintering including pelletization, production of pig iron or steel, and production and processing of ferrous metals where combustion installations with a total rated thermal input exceeding 20 MW are operated.

⁴³ Another primary production process involves use of direct reduction plants to produce direct reduced iron (DRI), which can then be fed to an electric arc furnace to make steel; while commercial, this technology is not however widely used.

⁴⁴ Fraunhofer Institute for Systems and Innovation Research, 'Methodology for the Free Allocation of Emission Allowances in the EU ETS Post 2012: Sector Report for the Iron and Steel Industry' (Utrecht: Fraunhofer ISI, 2009), at 7 <https://ec.europa.eu/clima/sites/clima/files/ets/allowances/docs/bm_study-iron_and_steel_en.pdf> (accessed 6 February 2021).

primary production facilities using the BOF process, whereas 41% originated from secondary production using the EAF process.⁴⁵

The production process also affects the degree of vertical integration and concentration in the industry. Primary production from iron ore mainly occurs in fully or partially integrated facilities,⁴⁶ typically operated by large national and multinational steelmaking companies, whereas secondary production from scrap steel frequently occurs in mini-mills that only consist of a steel furnace and rolling and finishing facilities.⁴⁷ A privatization wave several years ago diminished state ownership of steel production. Steel production facilities are large, highly specialised, complex and durable assets which require substantial capital outlays leading to significant fixed production costs and necessitating very high-capacity utilisation for break-even.⁴⁸

The steel sector is responsible for a large variety of products, which are grouped into three main categories: crude steel (HS Codes 7204-7205), semi-finished products (HS Codes 7206-7207), and finished products (HS Codes 7208-7229, 73). Semi-finished products include intermediate castings such as blooms, billets, slabs, and ingots, and finished products include flat products, long products, and alloyed steels.⁴⁹ These products are major components in buildings, automobiles, tools, and appliances, with the construction and automotive sectors as the two largest steel end users in Europe.⁵⁰

Substitutes depend on the end use, with aluminium, cement, and wood able to substitute for steel in construction, and aluminium and fibreglass or other plastics replacing steel in automobile manufacturing. Substitution is impeded in the short run by high switching costs in

⁴⁵ EUROFER, *supra* note 1, at 16.

⁴⁶ Fully integrated facilities include coke ovens on site, whereas partially integrated facilities outsource coke production.

⁴⁷ Christian Egenhofer et al., 'The Steel Industry in the European Union: Composition and Drivers of Energy Prices and Costs' (Brussels: CEPS, 2013) <<https://www.ceps.eu/wp-content/uploads/2013/12/Steel%20Report.pdf>> at 3 (accessed 6 February 2021).

⁴⁸ Egenhofer et al., *supra* note 41, at 12.

⁴⁹ Yeen Chan et al., 'Industrial Innovation: Pathways to Deep Decarbonisation of Industry – Part 1: Technology Analysis' (London: ICF Consulting Services Ltd. et al., 2019), at 4-5 <https://ec.europa.eu/clima/sites/clima/files/strategies/2050/docs/industrial_innovation_part_1_en.pdf> (accessed 6 February 2021).

⁵⁰ EUROFER, *supra* note 1, at 25.

the downstream production processes.⁵¹ Steel is traded almost exclusively in the form of semi-finished and finished products. Steel mills and suppliers deliver steel products to intermediaries in steel distribution – including steel service centres, stockists and traders – or directly to end users.⁵² In the EU, roughly two-thirds of steel sales occur through intermediaries servicing low-volume customers based on spot prices, while the larger end users – such as automobile manufacturers – tend to purchase steel directly on the basis of negotiated contracts.

3.4.2 Environmental Considerations

Carbon intensity of steel production differs greatly based on the production process, with primary steel production from iron ore generally much more energy- and therefore carbon intensive than secondary production from scrap steel. In primary steel production, CO₂ emissions occur from fuel combustion in the coking and sintering process, hot metal production in the BF, and its conversion to steel in the BOF. Additionally, primary steel production releases process emissions from the carbon used as a reducing agent in the blast furnace and from limestone calcination. Globally, an average 2,3 tonnes of CO₂ are released for every tonne of steel produced from integrated steelmaking, and while European steelmakers are more efficient than the global average, they still release, on average, 1,9 tonnes of CO₂ per tonne of steel.⁵³

For crude steel produced in EAF route, meanwhile, direct emissions arise from fuel used to achieve the high temperatures needed to melt the scrap steel, as well as from the carbon contained in the electrodes. Direct emissions can be as low as 0,1 tonnes of CO₂ per tonne of product, not counting the indirect emissions from electricity, which currently add 0,1 to 0,3 tonnes of CO₂ per tonne of steel, but can be reduced to zero by relying on renewable electricity.⁵⁴ In spite of the large variety of products in the steel sector, thus, by far the largest

⁵¹ Egenhofer et al., supra note 41, at 12.

⁵² EUROFER, supra note 1, at 23.

⁵³ Material Economics, 'Industrial Transformation 2050: Pathways to Net-Zero Emissions from EU Heavy Industry' (Cambridge: CISL, 2019), at 73 <<https://materialeconomics.com/publications/industrial-transformation-2050>> (accessed 6 February 2021).

⁵⁴ Material Economics, supra note 47, at 73.

share – almost 90% – of its carbon emissions can be attributed to the upstream production of coke, sinter, BOF crude steel and EAF crude steel.⁵⁵

Within each production process, the highly competitive nature of the steel sector has already resulted in convergence of process efficiency levels. Remaining differences in emissions intensity between facilities using the same process are therefore mostly due to the fuels used for industrial heat, as well as – regarding indirect emissions – the emission factor of electricity sourced from outside the facility.⁵⁶ Expansion of secondary steel production using EAF process could help reduce the carbon intensity of steel production if the electricity used in the process were generated from renewable sources, but any such expansion would be contingent on an increase in the availability of scrap steel, and thus require considerable improvements in the sorting process and collection rate.

Further reductions in the carbon intensity of steel production can be achieved through two main technological pathways: improved integration of conventional processes combined with carbon capture, utilization and storage; or processes to avoid carbon emissions altogether, for instance by using renewable hydrogen or electricity as a source of process heat and as a reduction agent.⁵⁷ Deploying these technologies at scale has been estimated to increase total cost of production by 35 to 100% per tonne of steel by 2050,⁵⁸ and significantly affect the investment cycle of steel plants.

3.4.3 Trade Patterns

Europe imports more steel than it exports, with the two main trading partners located along the east and southeast border, but also significant imports from East and South Asia. The five largest sources of steel imports are Turkey, Russia, South Korea, China and India, whereas Europe primarily exports steel to Turkey, the United States, Switzerland, Algeria and Mexico.⁵⁹ Recent years have seen a surge in trade defence measures deployed by the EU against a number of

⁵⁵ Fraunhofer Institute, *supra* note 38, at 8-9.

⁵⁶ It bears noting, however, that up to four fifths of electricity needs in the steel sector are covered by electricity produced on site with waste gas, see Fraunhofer Institute, *supra* note 38, at 8.

⁵⁷ EUROFER, 'Low Carbon Roadmap: Pathways to a CO₂-Neutral European Steel Industry' (Brussels: EUROFER, 2019), at 4-5 <<https://www.eurofer.eu/assets/Uploads/EUROFER-Low-Carbon-Roadmap-Pathways-to-a-CO2-neutral-European-Steel-Industry.pdf>> (accessed 6 February 2021).

⁵⁸ EUROFER, *supra* note 51, at 7.

⁵⁹ EUROFER, *supra* note 1, at 41-47.

trade partners, underscoring the complexity of trade flows, the high degree of government intervention in foreign steel production, and the impacts on competition from resulting excess production capacities. Anti-dumping proceedings have also contributed to dynamic shifts in production capacity, for instance from China to countries in Southeast Asia. As a result, exports have dropped in recent years, while imports have significantly increased, ending Europe's status as a net exporter of steel in 2014.

3.4.4 Other considerations

As a globally traded commodity, steel is imported into the EU from both neighbouring countries and from overseas. The main exporters of steel and steel products into the EU are Russia, Turkey, Ukraine, China and South Korea. Given the political and economic weight of several of these countries, including the particular sensitivities in EU-Russian and EU-Turkish relations, inclusion of steel imports in the scope of a CBAM is likely to result in substantial diplomatic conflict, as early informal statements from officials in some of these countries already have shown. At the same time, South Korea already has introduced a meaningful carbon price on steel, and other countries, such as Ukraine and China, have begun exploring carbon pricing for industry. Russia and Turkey may likewise consider carbon pricing in future. Still, even if carbon pricing is introduced, the stringency of carbon constraints is likely to remain substantially lower from that in the EU for the foreseeable future. Depending on how the CBAM takes into account foreign climate policy efforts, such initiatives can potentially reduce the geopolitical sensitivities associated with its introduction in the steel sector.

3.4.5 Implications for CBAM Design

With high carbon intensity and a deteriorating trade balance, steel would appear to be a natural candidate for application of a BCA. There are a number of challenges for BCA design and implementation that need to be addressed when including the sector in a simple BCA pilot phase: steel is characterized by a large variety of traded products, including semi-finished and finished products that consist almost exclusively of steel, while crude steel as such is not extensively traded. This suggests a need to expand the scope of any leakage safeguards to downstream products in the steel sector.

Also, alternative production processes have far-reaching implications for the carbon intensity of steel, and suggest that a CBAM should differentiate by production process. As emissions from electricity generation continue to decline across Europe, the lifecycle emissions intensity of steel produced from scrap using the EAF process will increasingly depart from the global average emissions intensity of steel made with this process. As European steelmakers shift to less carbon intensive production processes, this dynamic will extend to primary production. Substantial

overcapacity in the steel sector implies that foreign producers have latitude to absorb costs, and raises the risk of resource shuffling, with foreign producers able to substitute lower-carbon steel produced through EAF or DRI processes for the actually contracted, more carbon intensive sources of steel.

More favourably, however, antidumping and safeguard measures have contributed to a higher degree of scrutiny of foreign steelmaking practices, somewhat improving transparency of market and producer dynamics. Still, trade defence cases do not typically involve data on carbon intensities of production, are limited to specific steel products only, and do not necessarily reflect rapidly changing trade flows. As such, improved data can be a basis for better insight on historical market and trade practices, although more detailed and frequently updated information would be needed for application of a CBAM.

Such information may be critical to trace trading patterns and pre-empt widespread resource shuffling. Many of the largest trading partners are immediate neighbours to the EU, but important markets are also located in East and South Asia as well as the Americas, implying a broad geographic scope and greater potential for diplomatic tensions. While diminishing, steel exports from the EU remain important, implying a need to consider measures to secure the competitiveness of European steel in global markets.

3.5 Fertilisers

Sector Profile					
Annual Consumption (nitrogen fertilizer nutrient, million tonnes)⁶⁰			Covered Installations⁶¹		Plants in Value Chain⁶²
EU 27	11,3	Global	107,7	Ammonia: 29 Nitric acid: 34	Fertilizer & ammonia: 173
Complexity of Value Chain			Low-medium	Level of Integration	Medium
Trade Patterns (all fertilizers)					
Relative Weight of Imports and Exports⁶³					
Imports as a Share of Domestic Consumption (%)		29,5%		Exports as a Share of Domestic Production (%)	
				21,3%	
Main Sources of Fertilizer Imports (% of total imports, by value)					
Russia (31,1%)		Egypt (8,8%)		Belarus (8,4%)	
Algeria (7,7%)		Morocco (7,4%)			
					
					
Summary					
<p>Our focus is on nitrogen fertilizers - a sub-sector of chemicals with unique characteristics. Activities covered under the ETS are production of ammonia (mostly for CO₂ produced in process) and production of nitric acid (for NO₂ produced); both are considered at risk of leakage. Most emissions are direct, though some indirect emissions exist and are expected to increase due to electrification drive. Export intensity is not high, but is significant, and particularly so for some specific installations. The</p>					

⁶⁰ Fertilizers Europe. 2020. *Industry Facts and Figures 2020*. Global figures are for 2017; EU figures for 2018-2019.

⁶¹ EU. 2019. Compliance data for 2019. ETS Union Registry. Accessed at https://ec.europa.eu/clima/sites/default/files/ets/registry/docs/compliance_2019_code_en.xlsx

⁶² Communication from Fertilizers Europe.

⁶³ Eurostat, 2019 data. C20.15: Manufacture of fertilizer and nitrogen compounds. (Includes non-nitrogen fertilizers.)

downstream market (fertilizers as final goods) is relatively uncomplicated, meaning upstream application of a CBAM (at the level of ammonia, nitric acid and finished products) would address most risks of leakage and competitiveness impacts.

3.5.1 Market structure

Fertilizers are a sub-sector of the chemicals sector more broadly, but we deal with them here separately both because of their significance economically, and because as a sector they have several characteristics that set them apart from the broader chemicals sector.

Fertilizers are typically made up of three elements: nitrogen, phosphate and potassium. We focus here on nitrogen; because it has more significant GHG emissions, it is the only element of the fertilizer industrial complex to be covered under the EU ETS. Two activities under the broad heading of fertilizers have ETS benchmarks: production of ammonia and production of nitric acid.

Ammonia is produced in the EU from a feedstock of natural gas, from which hydrogen is broken out with steam and pressure (methane steam reforming). This stage of the process is the most GHG-intensive, both because of the energy needed, and because of the stream of CO₂ produced in the process of conversion. Hydrogen is then converted to ammonia, which is a fertilizer in its own right, but is usually transformed further for ease of handling and to optimize its end-use characteristics.

Ammonia can be transformed to nitric acid, which in turn can be used to make ammonium nitrate – a stable final form of fertilizer. The other main final form of nitrogen fertilizer is urea, also produced from ammonia. The process of producing ammonium nitrate from nitric acid releases significant amounts of nitrous oxide, a powerful GHG; this is why nitric acid production is covered under the ETS.

Production of ammonia, nitric acid, ammonium nitrate and urea tends to be carried out in integrated operations. Downstream purchasers are wholesalers that process, package, and sell to retailers. The downstream value chain is fairly direct and involves relatively few differentiated products.

The EU fertilizers sector is a mature sector, with the average age of plant around 45 years, and has seen little significant capital investment in recent years. As such, the coming decade will be

important in determining the kind of capital that will characterize this sector out to 2050, and the need for certainty of investment decisions is critical.

3.5.2 Environmental considerations

The EU uses natural gas as a feedstock to hydrogen production, and producers pay relatively more for it than do producers in countries such as Russia. As a result, EU producers have been motivated to find operational efficiencies. The CO₂ emissions per tonne of ammonia produced in the EU range from 1,6 to 2,3, averaging 1,9. That compares to Russia with an average of 2,4. China's average is closer to 5, since they tend to gasify coal for their feedstock (though that is slowly changing).

Most plants use natural gas as a fuel for creating pressure and heat, so almost all emissions are direct. There are, however, a few European plants that have electrified their pressurization processes, and those plants have significant indirect emissions, embodied in their purchased electricity. Other plants are expected to electrify due to decarbonization efforts.

Emissions of nitrous oxide from nitric acid production in the EU have fallen by 93% of what they were at the outset of the ETS. EU producers have invested in costly catalyzers that destroy it.

There are two major low-carbon pathways in this sector.⁶⁴ One is the production of hydrogen through renewable-energy powered electrolysis, avoiding the significant CO₂ emissions from using natural gas. At present this is a much more costly option than the conventional technologies. The other is carbon capture and storage (CCS), targeting the CO₂ generated by the methane steam reforming process that currently produces hydrogen.

There is some potential for resource shuffling in this sector. Foreign operators with more than one plant (many producers in Russia are more than single plant operations, for example) will certainly be motivated to divert the cleanest production toward EU export.

⁶⁴ ICF/Fraunhofer ISI. 2019. Industrial Innovation | Part 1: Technology Analysis.

3.5.3 Trade patterns⁶⁵

The traded products in this sector tend to be final products (finished fertilizers), as opposed to intermediate goods (ammonia and nitric acid). In 2019, the value of EU production of all fertilizers and nitrogen compounds was €16,6 billion, of which exports amounted to 21,3%, or €3,5 billion. Major export destination countries were Ukraine at 10,5% of total exports, Brazil at 8,9% and China at 5,9%. The EU has a deficit in fertilizers trade, and imported 5,4 billion in 2019. The major source countries were Russia at over 31,1% of total imports, followed by Egypt, Belarus, Algeria and Morocco at between 9 and 7% of total imports apiece.

The sector overall sells most of its product – almost 80% -- within the EU 27. But at the level of specific plants the picture is varied. A few larger plants are set up primarily for export.

The natural gas feedstock used in nitrogen fertilizer production is virtually all imported, mostly from Russia.

3.5.4 Other considerations

The major countries of import, as noted above, are Russia, Egypt, Belarus, Algeria and Morocco. None of these countries have carbon pricing in place, and thus they would all be vulnerable to a CBAM even if it were to credit for foreign carbon pricing. If a CBAM were instituted Russia, as a supplier of almost a third of total fertilizer imports to the EU, would be the most significantly affected, though as noted above there is some potential for resource shuffling among Russian installations.

3.5.5 Implications for CBAM design

In the drive to net-zero by 2050, in addition to some retrofitting, the vast majority of the existing stock of ammonia plants in the EU will have to be completely replaced. The current outlook for low-carbon capital investment involves significant costs over and above conventional production. While those technologies can be expected to improve and become less costly over time, they will still involve cost premiums that, if undertaken in the EU without CBAM or other instruments, could lead to significant competitiveness impacts and carbon leakage, either as lost market share, or in the form of relocation.

The relatively simple downstream structure of the fertilizers sector lends itself well to upstream coverage of a CBAM. The fact that nitrogen content of any imports must eventually be declared

⁶⁵ Data in this section based on Eurostat 2019 data, C20.15: Manufacture of fertilizer and nitrogen compounds. They include all fertilizers, including non-nitrogen fertilizers.

makes it more straightforward to apply any carbon calculation, whether benchmark or product-based, to imports.

The low levels of indirect emissions might be seen to argue for only scope 1 coverage in a CBAM, but this would place some firms at a disadvantage: those that have invested in electrification of compressors at their operations. It would also militate against one of the key routes to future decarbonization of the sector: more widespread process electrification.

Export coverage of a CBAM would be important for this sector. While a 21% share of exports may not be as high as in other sectors, there are specific plants for which that proportion is much higher and for whom this is a critical issue.

3.6 Non-Ferrous Metals

Sector Profile ⁶⁶					
Annual Production (Primary Aluminium) 2018			Covered Installations⁶⁷		Plants in Value Chain
EU 28	2,2 Mt	Global	64,2 Mt	159 (includes EFTA States)	~900
Complexity of Value Chain			Medium	Level of Integration	Low
Trade Patterns ⁶⁸					
Relative Weight of Imports and Exports (aluminium, by value)					
Imports as a Share of Domestic Consumption (%)		36,6%		Exports as a Share of Domestic Production (%)	
				23,7%	
Main Sources of Imports (% of total imports, by value)					
Norway (18%)	Russia (14%)	China (9%)	UAE (7%)	Switzerland(7%)	
					
Summary					
<p>Non-ferrous metals are highly energy intensive (and, in particular, electricity intensive) and widely traded, with a global reference price for the base metals that impedes passing through carbon cost. The value chains of non-ferrous metals are complex, and many face competition from substitutes. Indirect emissions from electricity use greatly exceed direct emissions due to electrochemical production processes for the primary production of base non-ferrous metals. Because of the impact of the carbon price on the marginal cost of electricity across European power markets, indirect carbon costs are high despite lower-than-average indirect emissions of European producers. For the largest non-ferrous metal in terms of volume and emissions, aluminium, the EU covers approximately half of demand through imports. A sizable share of imports originates from EFTA countries (which are subject</p>					

⁶⁶ Data for primary aluminium production in the EU28 in 2018: European Aluminium, ‘Digital Activity Report: 2018-2019’ <<https://www.european-aluminium.eu/activity-report-2018-2019/market-overview>> (accessed 6 February 2021); data for global primary aluminium production in 2018: International Aluminium Institute, ‘Primary Aluminium Production’ <<https://www.world-aluminium.org/statistics/#data>> (accessed 6 February 2021).

⁶⁷ Based on European Commission, ‘Compliance Data for 2019. ETS Union Registry’ (2019) <https://ec.europa.eu/clima/sites/default/files/ets/registry/docs/compliance_2019_code_en.xlsx> (accessed 12 March 2021), counting production of primary aluminium, production of secondary aluminium, and production or processing of non-ferrous metals, but not counting metal ore roasting or sintering and combustion installations with a thermal rating of 20 MW or more.

⁶⁸ Data for PRODCOM 2442 (Aluminium production) for 2019 from Eurostat, ‘Sold Production, Exports and Imports by PRODCOM list (NACE Rev. 2)’ <<https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do>> (accessed 6 February 2021).

to the EU ETS), although the share of Chinese imports, in particular, has seen dramatic growth, stimulated by production subsidies and excess production capacities. Given that it represents the largest share in terms of emissions and volume among non-ferrous metals, aluminium is the focus of this analysis. However, the particularities of aluminium also apply to other energy intensive non-ferrous metals such as copper, zinc, nickel and silicon.

3.6.1 Market Structure

Non-ferrous metals are metals other than iron, including aluminium, copper, nickel, lead, zinc, tin, and alloys thereof. Production and processing of non-ferrous metals are covered activities under the EU ETS,⁶⁹ and the leakage list for phase 4 of the EU ETS (2021-2030) deems production of aluminium (NACE Code 24.42), lead, zinc, and tin (NACE Code 24.43), copper (NACE Code 24.44), other non-ferrous metals, including nickel (NACE Code 24.45), manufacture of other inorganic chemicals, including silicon (NACE Code 20.13) and manufacture of basic iron and steel and of ferro-alloys, including ferro-manganese and ferro-silicon (NACE Code 24.10)⁷⁰ to be at risk of carbon leakage.⁷¹ These sectors are also deemed as exposed to a significant risk of carbon

⁶⁹ Specifically, Annex I of Directive 2003/87/EC lists production of primary aluminium, production of secondary aluminium using combustion units with a total rated thermal input exceeding 20 MW, and production or processing of non-ferrous metals using combustion units with a total rated thermal input exceeding 20 MW.

⁷⁰ This sector profile only considers activities covered by NACE Code 24.10 other than iron and steel, which are covered by the sector profile on ferrous metals.

⁷¹ European Commission, 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, OJ 2019 L120/2 <<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019D0708>> (accessed 6 February 2021).

leakage due to the indirect costs of the EU ETS under the eligibility list of the 2021-2030 ETS State Aid Guidelines.⁷²

More than half of greenhouse gas emissions from non-ferrous metals is attributable to aluminium production,⁷³ and this sector profile therefore focuses on aluminium production. Many particularities of aluminium, however, also apply to other non-ferrous metals.

Aluminium

Aluminium is an abundant metal with low density, high conductivity and ductility, and favourable corrosion resistance. In the primary production process, aluminium is produced from the ore bauxite, which is purified to yield aluminium oxide (Al_2O_3) – also known as alumina – and reduced to elemental aluminium in smelting plants through the electrochemical Hall–Héroult process, which requires temperatures in excess of 950°C and a high intensity electrical current. Secondary aluminium is refined or remelted from scrap metal recovered from waste and recycling streams, requiring a melting furnace operating at temperatures ranging from 700°C to 760°C, mostly using natural gas.

Downstream, unwrought aluminium (HS Code 7601) in the form of pure or alloyed ingots, blocks, billets, slabs and similar forms is converted into flat rolled, extruded, and cast products, including semi-finished bars, rods and profiles (HS Code 7604), wire (HS Code 7605), plates, sheets and strips (HS Code 7606) as well as foil (HS Code 7607).⁷⁴ Aluminium waste and scrap (HS Code 7602) are also extensively traded. Due to its favourable physical characteristics, aluminium has seen rapidly growing use in the transport industry, building and construction, packaging and consumer durables, as well as technical applications. Substitutes include

⁷² European Commission, Communication from the Commission: Guidelines on Certain State Aid Measures in the Context of the System for Greenhouse Gas Emission Allowance Trading Post-2021 (2020/C 317/04), OJ 2020 C317/5. <<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020XC0925%2801%29>> (accessed 6 February 2021). The list of eligible sectors is contained in Annex 1.

⁷³ Yeen Chan et al., 'Industrial Innovation: Pathways to Deep Decarbonisation of Industry – Part 1: Technology Analysis' (London: ICF Consulting Services Ltd. et al., 2019), at 80 <https://ec.europa.eu/clima/sites/clima/files/strategies/2050/docs/industrial_innovation_part_1_en.pdf>.

⁷⁴ Fraunhofer Institute for Systems and Innovation Research, 'Methodology for the Free Allocation of Emission Allowances in the EU ETS Post 2012: Sector Report for the Iron and Aluminium Industry' (Utrecht: Fraunhofer ISI, 2009), at 1 <https://ec.europa.eu/clima/sites/clima/files/ets/allowances/docs/bm_study-aluminium_en.pdf> (accessed 6 February 2021).

composites, magnesium, steel, and titanium in transport, glass, paper, plastics, and steel in packaging, composites, steel, vinyl, and wood in construction, and copper in electrical and heat-exchange applications.⁷⁵

Smelters and rolling mills are often owned by multinational companies, while the majority of the plants involved in extrusion and recycling are small to medium enterprises (SMEs).⁷⁶ Vertical integration across the value chain is less common with EU producers than with producers in some trade partners, such as China. Europe represents about 7 percent of global production, around half of which comes from within the EU. The number of aluminium smelting plants in the EU has decreased from 26 plants in 2002 to 15 plants in 2019, located in ten countries: France, Germany, Greece, The Netherlands, Spain, Romania, Slovakia, Slovenia. In addition, the value chain of aluminium in the EU comprises around 600 plants ranging from the raw materials to semi-fabrication and recycling.⁷⁷

Aluminium is mostly traded in the wholesale market, with negligible retail sales. A sizeable share of aluminium demand in the EU – approximately 14% - comes from stockists that hold the metal in warehouses. Unlike many basic materials, aluminium and other non-ferrous metals are traded at a recognised investment exchange, the London Metal Exchange (LME), providing a liquid market and global reference price for the base metal. For semi-finished and finished products, the base metal is priced at this reference price, with a negotiated premium for the value added in downstream production. As such, the aluminium sector is a price taker and unable to pass through the price of carbon to its customers without losing significant market share.

Other Non-ferrous Metals

With regard to the other base metals – notably copper, zinc, nickel, silicon and ferro-alloys – the market structure is similar. The supply chain includes various stages with significant cross-border trade. It can be summarized as follows, starting upstream: mining of mineral ores and concentrates; smelting and refining of metals; recycling; casting, shaping, and profiling, and metalworking and finished articles. The upstream production is the most energy and capital-intensive, and thus involves the largest companies. Metals processors and fabricators tend to follow a more fragmented structure, with a larger share of SMEs. Overall, European non-ferrous

⁷⁵ U.S. Geological Survey, 'Mineral Commodity Summaries: Aluminum' (January 2021) <<https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-aluminum.pdf>> (accessed 6 February 2021).

⁷⁶ European Aluminium, 'Digital Activity Report: 2018-2019', supra note 58.

⁷⁷ European Aluminium, 'Digital Activity Report: 2018-2019', supra note 58.

metals facilities across Europe amount to more than 900 (including aluminium). Europe is highly dependent on imports of metal ores and concentrates: in the range of 60 to 100%, by weight.⁷⁸ European non-ferrous metals roughly meet 1% of the mining global market share, by weight. The smelting and refining players represent around 6% of the world total, by weight.⁷⁹ Importantly, European recyclers have a much more predominant position globally, reaching a 24% market share. Overall, non-ferrous metals are used in buildings, transport, electronics, power generation, transmission, and storage, and connectivity. Due to their high price elasticity of demand, non-ferrous metals are price-takers, traded in global markets, such as the LME.

Outlook: Growing Demand

Global and EU demand for non-ferrous metals is expected to increase dramatically over the next three decades, given their various uses in low-carbon technologies. In 2017, the World Bank concluded that demand for metals is forecast to rise significantly in key low-carbon applications by 2050: wind turbines (-/+300%); solar panels (-/+200%); and energy storage (-/+ 1000%).⁸⁰ The OECD's 2018 Raw Materials Outlook confirms the rising need for metals and forecasts an increase from 7 to 19 Gt per year by 2060.⁸¹ Metals are essential for low-carbon technologies. For example, aluminium is replacing steel in lighter-weight vehicles; copper is used for electronic components and motors in electric vehicles, solar panels, wind turbines, and fuel cells in hydrogen-powered vehicles; battery metals such as cobalt, lead, lithium, manganese, and nickel

⁷⁸ See European Commission, 'Critical Raw Materials' (2020) <https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en> (accessed 6 February 2021).

⁷⁹ Copper is 13%, nickel 9,6%, zinc 13,4%, and aluminium at 4% at the EU level, or 7% including EFTA, see Tomas Wyns and Gauri Khandekar, 'Metals in a Climate Neutral Europe: A 2050 Blueprint' (Brussels: IES, 2020) 10 <https://www.ies.be/files/Metals_for_a_Climate_Neutral_Europe.pdf> (accessed 6 February 2021).

⁸⁰ World Bank, 'Growing Role of Minerals and Metals for a Low Carbon Future': <<http://documents.worldbank.org/curated/en/207371500386458722/pdf/117581-WP-P159838-PUBLIC-ClimateSmartMiningJuly.pdf>> (accessed 6 February 2021).

⁸¹ OECD, 'Global Material Resources Outlook to 2060' <https://read.oecd-ilibrary.org/environment/global-material-resources-outlook-to-2060_9789264307452-en#page1> (accessed 6 February 2021).

are essential for clean mobility and grid storage batteries; zinc and cobalt for protecting off-shore wind turbines; and silicon in solar panels.

Global Market Dynamics

The global metals market is chiefly dominated by China. China is the world's largest producer of non-ferrous metals.⁸² Between 2008 and 2016, its global market share has soared from 34% to 54% in the case of aluminium, from 20% to 35% for copper, from 15% to 30% for nickel or from 33% to 46% for zinc. The surge of this industry in China is the result of a string of government support programmes⁸³ which identify these non-ferrous metals as being of "strategic importance to the Chinese economy and its further development". Such government intervention has brought about chronic overcapacities.⁸⁴

3.6.2 Environmental Considerations

Non-ferrous metals are a major source of greenhouse gas emissions, but the properties of non-ferrous metals – notably their low density, resistance to oxidation and abrasion, hyperconductivity of heat and power, and limitless recyclability – also make it a material capable of delivering mitigation benefits across a variety of applications.⁸⁵

Aluminium

Primary aluminium production is a multi-stage and energy-intensive process, with electrochemical reduction of alumina consuming the largest share of energy, followed by alumina production from bauxite ore. These processes result in direct emissions of CO₂ from use of fuels for process heat as well as CO, perfluorocarbons (PFCs) and smaller amounts of CO₂ through carbon anode consumption and anode effects. Direct emissions are relatively homogenous across primary aluminium production plants, and range from 2 to 2,5 tCO₂e per tonne of aluminium. Because of the electrolytic reduction process, however, indirect emissions greatly outweigh direct emissions in primary aluminium production. In the EU, indirect

⁸² Wyns et al., supra note 70, at 26.

⁸³ Cf., for instance, the 'Strategic Emerging Industry Initiative' (2009) or the 'Made in China 2025' Plan

⁸⁴ Markus Taube, 'Analysis of Market-Distortions in the Chinese Non-Ferrous Metals Industry' (Munich: THINK!DESK China Research & Consulting, 2017), at 130-133 <https://eurometaux.eu/media/1624/study_-analysis-of-market-distortions-in-china.pdf> (accessed 6 February 2021).

⁸⁵ Chan et al., 'Industrial Innovation', supra note 64, at 82. For example, aluminium's lightweight properties have enabled cars produced in Europe in 2019 to prevent an estimated 50 Mt CO₂e in vehicle emissions during their lifetime, see Wyns et al., supra note 70.

emissions average 7 tCO₂e per tonne of aluminium, whereas they average 16,5 tCO₂e per tonne of aluminium globally, are as high as 20 tCO₂e on average per tonne of aluminium produced in China, and can be as low as 1,5 tCO₂e per tonne of aluminium in regions with very high shares of hydroelectric generation.

Because of the high electricity intensity of primary aluminium production, electricity costs represented on average 37% of total production costs of primary aluminium producers in the EU, and increased from €461 per tonne of aluminium in 2008 to €542 per tonne in 2017.⁸⁶ As a result, the sector is also highly exposed to indirect costs resulting from the EU ETS, notably the impact of the carbon price on the marginal cost of electricity in EU power markets. Growing interconnection between power regions across the EU results in partial pass-through of indirect costs even to smelters that procure power from grids with low or no emissions. Averting leakage in the aluminium sector – and, mutatis mutandis, in most other non-ferrous metals – requires a solution to the challenge of indirect carbon costs, yet the different pass-through factors across Europe impede the calculation of a single European pass-through factor.

Production of secondary aluminium from scrap and recycled aluminium requires only approximately 5% of the energy used to produce aluminium from ore, although a significant part of the input material is lost as dross. A 10% increase in aluminium recycling rates can thus decrease greenhouse gas emissions from the sector by 15 percent.⁸⁷ For secondary aluminium plants, electricity costs were accordingly €31 per tonne of aluminium in 2016, falling to €27 per tonne in 2017.⁸⁸ Already, secondary aluminium production in the EU exceeds primary production by a factor of two,⁸⁹ and the recycling rate of aluminium – especially from packaging – continues to increase, currently reaching approximately 40%.⁹⁰

Aside from shifting production to the secondary production process, process improvements, a drastic reduction of PFC emissions, the closure of several smelters and continued decarbonisation of the power grid have helped the aluminium sector reduce direct and indirect

⁸⁶ Christian Egenhofer et al., ‘Composition and Drivers of Energy Prices and Costs in Energy Intensive Industries’ (Brussels: CEPS, 2018) <https://www.ceps.eu/wp-content/uploads/2019/01/ET0318091ENN.en_.pdf> at 150-151 (accessed 6 February 2021).

⁸⁷ Aluminum Association, ‘Secondary Production’ <<https://www.aluminum.org/industries/production/secondary-production>> (accessed 6 February 2021).

⁸⁸ Egenhofer et al., ‘Composition and Drivers’ supra note 77.

⁸⁹ European Aluminium, ‘Digital Activity Report: 2018-2019’, supra note 58.

⁹⁰ Chan et al., ‘Industrial Innovation’, supra note 64, at 88.

greenhouse gas emissions by 50% since 1990.⁹¹ Going forward, the decarbonisation options for aluminium are broadly categorised into four main categories: decarbonisation of electricity generation, further process improvements on current manufacturing techniques, new production techniques using innovative technologies (inert anode), and feedstock innovations that draw on improved techniques to treat alumina, or sourcing aluminium from new materials with a smaller CO₂ footprint. Full decarbonisation of aluminium production will however also rely on end-of-pipe carbon capture and sequestration (CCS) solutions.

Other Non-Ferrous Metals

The same also holds true for other non-ferrous metals, which are likewise extremely electricity intensive: power represents 38,5% of the operational costs of zinc, 35% of silicon, 27% of the production costs of copper, and 19% of nickel.⁹² This electricity intensity of non-ferrous metals is thus significantly higher than that of most other energy-intensive materials.

With regard to the share of emissions, indirect emissions are significantly higher than direct emissions: aluminium: 25,5% direct vs. 75,5% indirect emissions; zinc: 27% direct vs. 73 indirect emissions; silicon: 49% direct vs. 51 indirect emissions; nickel: 17% direct vs. 83% indirect emissions; copper: 43,8% direct vs. 56,2 indirect emissions; ferro-manganese: 33% direct vs. 67% indirect emissions; and ferro-silicon: 47% direct vs. 53% indirect emissions.⁹³

As with aluminium, the main option for decarbonisation of the other non-ferrous metals is the further decarbonisation of the power sector. Non-ferrous metals have already reduced their carbon footprint by 60% compared to 1990 levels. The remaining 40% are expected to come from emissions reductions from a decarbonised power source (21%) and from the deployment of breakthrough technologies, energy efficiency improvements and bio-feedstock innovations (19%).⁹⁴ It is also worth noting that recycled non-ferrous metals constitute around 50% of EU

⁹¹ Chan et al., 'Industrial Innovation', supra note 64, at 87.

⁹² Wyns et al., supra note 70, at 68.

⁹³ The share of direct vs. indirect emissions can be found in Wyns et al., supra note 70, at 51.

⁹⁴ Wyns et al., supra note 70, at 16.

total base metals production, while for the rest of the world, the share of recycled metals represents only around 18%.⁹⁵

3.6.3 Trade Patterns

Despite growing demand for non-ferrous metals, the demand is being met by increased imports with EU production meanwhile declining.

Aluminium

Around half of EU aluminium demand is covered through imports. A significant share of these imports originates in European Free Trade Agreement (EFTA) countries, notably Norway, Switzerland and Iceland. Since these countries already participate in the EU ETS or a linked emissions trading system, they are of less concern regarding emissions leakage than other trade partners. As of 2019, the largest producers of aluminium outside the EU are China, India, Russia, Canada, and the United Arab Emirates, with China having experienced dramatic growth in production capacity to represent about 60% of total global aluminium production. China raises particular concerns in terms of EU emissions leakage because it heavily subsidizes aluminium production⁹⁶, and has high excess production capacity. Coupled with substantial heterogeneity of indirect emissions per tonne of product, this excess capacity indicates significant potential for resource shuffling and other evasion tactics.⁹⁷ China has been known, for instance, to bring aluminium smeltered in its territory to the EU market through downstream processing and finishing in third countries such as Vietnam, benefitting from the favourable tariffs in place between those countries and the EU. To take another example, Chinese producers could redirect the 10% of Chinese aluminium production based on hydroelectric power for export to the EU, and retain the remaining 90% of aluminium – much of which is produced with coal-fired

⁹⁵ For example, 43% of Europe's copper use in semi-finished and finished products is already covered by secondary production; for zinc and nickel, the figures stand at 30% (1.05 Mt) and 33% (0.7 Mt) respectively, see Wyns et al., supra note 70, at 32-33.

⁹⁶ A recent OECD report concluded that 85% of subsidies in the aluminium sector went to 5 Chinese companies: OECD, 'Measuring Distortions in International Markets: The Aluminium Value Chain' (Paris: OECD, 2019), <https://www.oecd-ilibrary.org/trade/measuring-distortions-in-international-markets-the-aluminium-value-chain_c82911ab-en> (accessed 6 February 2021).

⁹⁷ 90% of Chinese primary aluminium production is based on coal-fired electricity generation, whereas the remaining 10% is based on hydropower, see World Aluminium, 'Primary Aluminium Smelting Power Consumption' (2020) <<http://www.world-aluminium.org/statistics/primary-aluminium-smelting-power-consumption>> (accessed 6 February 2021).

electricity – for their local market or third countries. Such resource shuffling would diminish or even negate any positive effect of a CBAM on global emissions.

Finally, the knock-on effects in the value chain should also be considered. Applying a CBAM only upstream would lead to higher costs for downstream producers, either incentivizing the relocation of production out of Europe or increasing imports of products at the next step in the value chain. For instance, if only primary aluminium were covered by a CBAM, road wheel producers in the EU might move production out of Europe, or European original equipment manufacturers (OEMs) would source finished aluminium road wheels from abroad.

Other Non-ferrous Metals

With regards to other non-ferrous metals, the trade patterns follow a similar path. The situation of European producers not benefiting from global growth is the same for the nickel sector. Statistics from the International Nickel Study Group show that global nickel production experienced growth of 4% annually (from 1.337 kt to 2.076 kt) between 2006 and 2017.⁹⁸ In the same time period, nickel metal production in the EEA experienced a growth of only 0,2% annually (from 198 kt to 203 kt). Chinese nickel production in the same period increased by 14% annually. While demand for refined copper in Europe has been growing by about 12% from 2013 to 2017, this has not led to increased investments or outputs within the EU copper industry. Production growth between 2013 and 2018 was only about 4,6%. Although net imports of total copper (NACE 2444) versus EU domestic production are moderate (0,46% to 3%), smelted and refined copper imports are substantial, and have increased from 20% in 2013 to 30% in 2018. Most smelting and refined copper production is happening in Asia. Likewise, a large share of new production capacity for copper and copper alloy semifinished goods has been created in Asia.

Zinc shows the same trend, as its demand surplus of approximately 200 kt per year is being met by imports from non-EU countries. These imports typically come from countries with more carbon-intensive production processes, such as Kazakhstan, Namibia or Mexico.

The European ferro-alloys and silicon industry is able to meet around one third of the European demand. As imports by far outweigh exports as well as domestic supply, the price pressure exerted by imports from third countries has prompted the closure of a number of European plants in recent years. The remaining European producers are now defending an already

⁹⁸ International Nickel Study Group, 'Annual Production Statistics' (2017) <www.insg.org> (accessed 6 February 2021).

diminished share of the global market. At the same time, certain non-ferrous metals are still seeing relevant levels of exports: the share of EU ferro-alloys production dedicated to exports outside the EU rose from 15% to 53% between 2008 and 2009, before levelling out at 30% between 2010 and 2017. Additionally, 11,2% of EU-produced silicon has been dedicated to exports.

3.6.4 Other considerations

Outside of EEA and EFTA countries, where non-ferrous metal producers are already subject to the EU ETS or a linked ETS, the main trade partners exporting aluminium and other non-ferrous metals to the EU are Russia and China, both of which are politically influential actors that could leverage a number of strategic interests to oppose the introduction of an EU CBAM. China, in particular, has seen considerable growth in both production capacities and exports to Europe. Given the average carbon intensities of production in these countries relative to the EU, a CBAM is likely to have a sizeable economic impact on export volumes and related revenue, although resource shuffling – if enabled by the design of the CBAM – could circumvent this burden. China is introducing a national carbon pricing system for electricity producers, which theoretically introduces a price on indirect emissions from non-ferrous metal production. Even so, however, the stringency of the Chinese ETS will matter, both in terms of its design and implementation, as well as with regard to the carbon price levels revealed in the carbon market. Importantly, the degree of cost pass-through to aluminium producers in China will depend on aspects such as the allocation method of allowances and the way electricity prices are determined, which may substantially blunt the price signal. Depending on whether and how the CBAM takes into account foreign climate policy efforts, this could lower the burden imposed on Chinese producers and mitigate some of the potential diplomatic tensions.

3.6.5 Implications for CBAM Design

Production of non-ferrous metals – including aluminium – is among the most energy-intensive activities covered by the EU ETS, and the share of imports into the EU has experienced long-term growth. Base metal prices are determined at the global level, impeding carbon cost pass-through. Still, providing investment certainty and averting competitiveness impacts as well as the resulting emissions leakage through inclusion of this sector within the scope of a CBAM faces significant challenges.

Elaborate upstream and downstream value chains, including a large number of semi-finished and finished products that consist almost exclusively of the base metals, incur administrative complexity. A relatively high share of exports also requires consideration, potentially outside the scope of a CBAM. Finally, heterogeneity of carbon intensities and excess production

capacities in trade partners – notably China – give rise to concerns about resource shuffling and evasion strategies. Large trade partners beyond EFTA include Russia and China.

Of particular concern with non-ferrous metals are indirect carbon costs related to the high electricity intensity of the sector. These costs accrue as a price effect in the European electricity market and are not directly related to the indirect emissions associated with production, which are what a CBAM covering indirect emissions would target. The indirect carbon costs are thus decoupled from actual emissions, since the electricity price is set by the marginal power plant, which is usually a fossil fuel plant. Consequently, electricity costs in the sector include the cost of carbon even in countries with a large share of emission-free power production.⁹⁹

For example, an aluminium smelter powered by hydroelectric generation would still face indirect carbon costs due to the fossil fuel marginal power plant determining the wholesale price of electricity, even though the electricity consumed would be carbon free. Such indirect carbon costs differ between regions and Member States, making it impossible to define a uniform value of indirect carbon costs in EU.

Thus, even if a CBAM could effectively include the indirect emissions associated with imports goods, it would be unable to reflect the indirect carbon costs that producers in Europe continue to face as a result of price increases in the power market. Compensation for these unilateral indirect carbon costs may therefore be needed to avoid placing European producers at a competitive disadvantage.¹⁰⁰

⁹⁹ For more on marginal pricing, see European Commission, 'Commission Staff Working Document: Impact Assessment' SWD(2016) 410 (30 November 2016) <https://ec.europa.eu/energy/sites/ener/files/documents/mdi_impact_assessment_main_report_for_publication.pdf> (accessed 6 February 2021).

¹⁰⁰ Given the electro-intensive nature of non-ferrous metals, the indirect costs of the EU ETS have a major impact on production costs of non-ferrous metals. For example, for primary aluminium production, if the EU ETS carbon price is €30 a tonne, indirect costs alone will represent 19% of production costs. This is too high a regulatory burden to bear. Similar figures can be seen for the primary production of other nonferrous metals such as copper, nickel, silicon, and zinc.

3.7 Pulp & paper

Sector Profile ¹⁰¹					
Annual Production (Pulp and Paper Board)				Covered Installations¹⁰²	Enterprises in Value Chain¹⁰³
EU 27	70.569 M€	Global	310.799 M€	Pulp: 170 Paper & board: 541	~117.000
Complexity of Value Chain			High	Level of Integration	Varied
Trade Patterns ¹⁰⁴					
Relative Weight of Imports and Exports					
Imports as a Share of Domestic Consumption (%)		Pulp: 44,7% Paper: 8,0%		Exports as a Share of Domestic Production (%)	
				Pulp: 38,7% Paper: 25,3%	
Main Sources of Paper & Board Imports (% of total imports, by value)					
US (17%) 		UK (15%) 		Switzerland (15%) 	
				Russia (11%) 	
				Norway (10%) 	
Main Sources of Pulp Imports (% of total imports, by value)					
Brazil (44%) 		US (18%) 		Uruguay (18%) 	
				Chile (8%) 	
				Russia (3%) 	
Summary					
<p>The pulp and paper sector consists of two distinct processing parts, with the pulping process feeding the papermaking process. Many different forms of vertical integration co-exist. Some mills integrate both pulp and paper manufacturing, with resulting efficiencies. Both pulp and paper manufacturing are energy-intensive and trade-exposed. Most emissions are the result of combusting fuels to generate steam and electricity. The sector is the second largest industrial consumer of electricity in the EU after chemicals, with around half of that electricity coming from co-generation on site, using biomass feedstock. Pulp production emissions intensity varies considerably, since some producers have access to biomass as a fuel, while others rely on natural gas, which results in higher carbon emission profiles. The sector has high levels of trade.</p>					

¹⁰¹EU data from EUROSTAT (C17.11, C17.12); global data from Statista. 2019 figures.

¹⁰² EU. 2019. Compliance data for 2019. ETS Union Registry. Accessed at https://ec.europa.eu/clima/sites/default/files/ets/registry/docs/compliance_2019_code_en.xlsx

¹⁰³ Eurostat dataset 'Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E) [SBS_NA_IND_R2__custom_688819]'. 2018 figures on the number of enterprises in EU27 for Pulp (17.11) and Paper & Board (17.12), Articles of Paper & Board (17.2), and Printing (18.1).

¹⁰⁴ UN Comtrade database (2019), HS47 (pulp, but minus 4707 which is recycling) and HS 48 (paper and paperboard, but minus some grades which are converted products).

3.7.1 Market structure

Manufacture of pulp and paper are covered under separate categories under the ETS: manufacture of pulp (NACE 17.11) and manufacture of paper (NACE 17.12). Both are considered at risk of leakage under the ETS phase IV, and are eligible for free allocation. Pulp manufacture from virgin wood fibre can be carried out by mechanical or chemical means, and recycled paper offers a third technology stream. Each process has its own ETS benchmark.¹⁰⁵ Pulp is then used as an input to papermaking – a process that differs markedly depending on the type of product required—e.g., coated paper, newsprint, tissue products, cardboard—and the quality desired.

The downstream value chain is varied, and includes a raft of products not covered under the ETS in sectors such as paper stationary, wallpaper, household sanitary goods, specialty paper, and corrugated paper and paperboard, and articles thereof. Paper and paper board has seven ETS benchmarks, and comprises over 50 different products in the NACE taxonomy. At the level of these final goods, the dynamics of leakage and competitiveness are different, not as acute. Products are differentiated on bases other than just cost, and carbon costs as a percentage of value are lower than in the upstream activities.

Levels of integration in the sector are varied. Integrated manufacture of pulp and paper is common, involving 12% of mills. Some companies own and manage forests and produce pulp to be sold on the market (market pulp), while others use the pulp they produce on their sites to produce paper and board (integrated pulp). Some need to buy market pulp to produce paper and board. Some produce paper & board and convert it to manufacture paper and board products. Some are trading the paper and & board they produce through merchant subsidiaries. Some paper and board companies also sell the electricity they produce on the grid or have invested in the paper for recycling collecting operations.

Markets for newsprint have been in secular decline for years, but the rise of e-commerce has created new demand for packaging. While overall production of paper and paperboard decreased in 2020 under pandemic conditions, there was actually growth for the production of

¹⁰⁵ There are two chemical process benchmarks, for sulphite pulping and kraft (sulphate) pulping.

packaging grades as well as sanitary and household grades.¹⁰⁶ Plastics are an important competing sector in the packaging market.

3.7.2 Environmental considerations

The main emissions result from combusting fuels to generate steam and electricity. The pulp and paper sector is the second-highest industrial user of electricity in the EU, after chemicals, with around half of that electricity coming from co-generation on site, using biomass feedstock. Pulp-making requires process steam, and paper-making requires heat for the drying of the paper web. Emissions intensity varies considerably, depending on the fuel mix. Most pulp makers use biomass for co-generation of heat and electricity, resulting in low emissions. Those emissions, though, are considered electricity production under the ETS and not eligible for free allocation.

Those installations not using biomass (some 40% of them) are typically using natural gas for heat and steam or, in those few places where electricity is cheap enough, using purchased electricity for industrial heat pumps and electric kilns. Pulp-making from the recycled fibre is significantly less energy-intensive, and recycling rates in the EU are relatively high at over 72% in 2019.¹⁰⁷ Emissions intensity for papermakers is less varied across the different products and processes than it is for pulp manufacture.¹⁰⁸

Low-carbon pathways using existing technologies focus on either energy efficiency or replacing natural gas as a fuel with low-carbon alternatives. New technologies seek to improve energy efficiency in processes such as the paper web drying process. Increased recovery and use of waste heat is also possible, though this practice is already widespread. Replacing natural gas with biogas, biomethane or green hydrogen, also manufactured on-site, is a possibility. However, their cost remains higher than natural gas per unit of energy. Producing steam with

¹⁰⁶ CEPI. 2021. Preliminary Statistics 2020.

¹⁰⁷European Paper Recycling council. 2020. Monitoring Report 2019: European Declaration on Paper Recycling 2016-2020.

¹⁰⁸ Fraunhofer ISI, ECOFYS and Öko-Institut. 2009. Methodology for the free allocation of emission allowances in the EU ETS post 2012 Sector report for the pulp and paper industry. By order of the European Commission.

electricity is possible, but less efficient and can be more costly than using natural gas. Several novel techniques are being developed to further reduce emissions.¹⁰⁹

3.7.3 Trade patterns

Pulp and paper is a relatively trade-intensive sector with a sizeable export stream; exports as a share of domestic production in 2019 were 38,7% for pulp and 25,3% for paper and board.¹¹⁰ The EU has a significant export surplus in paper and board products, with €18,5 billion exported in 2019 and €4,6 billion imported.¹¹¹ In pulp, imports were €4,6 billion and exports were €3,8 billion in 2019.¹¹²

While the global markets have experienced steady growth over the last 50 years, the EU's share of those markets has declined, from 32% in 1961 to 26% in 2016¹¹³. Most global growth in pulp production has come from South America, which has invested in fast-growing eucalyptus, and most growth in paper production has been in Asia.

3.7.4 Other considerations

There are two markets that would be affected by the imposition of an EU CBAM: the market for pulp, and the market for paper and board products. The pulp market imports are dominated by Brazil, at almost half of total imports. The EU constitutes a significant share of total pulp exports for Brazil at 26%¹¹⁴ which, given Brazil's lack of carbon pricing, makes it vulnerable. At 18% of imports, the US is the next biggest source, in a flow of trade that takes advantage of empty Chinese cargo ships returning from the US east coast to China, offering excellent freight rates. In the same vein, the US is the EU's top source of imported paper board, at 17% of total imports. The US, with a new administration that prioritizes climate ambition, and conscious of trade flows in sectors like pulp and paper, will undoubtedly push for the EU's acceptance of that ambition as a basis for exemption from CBAM coverage. The UK is the second most important source of paper and board imports, at 15%, and can be expected to push for the same sort of

¹⁰⁹ ICF/Fraunhofer ISI. 2019. Industrial Innovation | Part 1: Technology Analysis.

¹¹⁰ UN Comtrade database (2019), HS47 (pulp, but minus 4707 which is recycling) and HS 48 (paper and paperboard, but minus some grades which are converted products).

¹¹¹ Eurostat. 2019 data. C17.12: Paper and paperboard.

¹¹² Eurostat. 2019 data. C17.11: Pulp.

¹¹³ ICF/Fraunhofer ISI. 2019. Industrial Innovation | Part 1: Technology Analysis. , Figure 4.1

¹¹⁴ UN Comtrade data for HS 47 (Pulp of wood or other fibrous cellulosic material; waste and scrap of paper and paperboard), 2019 values.

consideration of its climate ambition. Switzerland is also an important source of paper and board imports, highlighting the importance of how that country is treated under any CBAM; while it is not part of the EU 27, it is part of the EU's ETS.

3.7.5 Implications for CBAM design

The major upstream activities manufacturing pulp and paper and board products would all likely be covered under a CBAM; these are currently covered under the ETS and are considered at risk of leakage for Phase 4 of the EU ETS.

The many downstream manufacturing activities that use those basic products, however, are not covered under the ETS – the manufacture of products such as paper stationary, wallpaper, household sanitary goods, specialty paper, and corrugated paper and paperboard. If those downstream producers were not covered under a CBAM, they might be at risk of leakage and competitiveness impacts.

This sector has high indirect costs. This argues for coverage of scope 2 emissions under a CBAM (or a continuation of indirect cost compensation under the ETS). It also has high carbon costs, which do not necessarily correspond to indirect costs. These are significant, and if a CBAM were to cover this sector there would need to be a complementary instrument to address these.

This sector relies on exports to a significant extent. A CBAM would need to cover exports if it were to avoid impairing EU producer competitiveness in global markets, or some other ways to address this issue would need to be put in place.

Plastics are an important competitor in the packaging market (aluminium and glass are also competitors to a lesser extent), so any pilot CBAM that covered pulp and paper should also cover chemicals, and vice-versa, or risk stimulating material substitution toward plastics.

3.8 Refined petroleum products

Sector Profile					
Annual Production ¹¹⁵ (in million t)			Covered Installations		Producers
EU	642	Global	4.173	~82 'mainstream' ¹¹⁶ refinery sub-installations in operation in 2016-17 ~135 in EU ETS countries; 122 in EU27 (2019) ¹¹⁷	~42
Complexity of Value Chain		Medium	Level of Integration		High
Trade Patterns ¹¹⁸ (for naphtha, motor gasoline, kerosene-type jet fuel, road diesel, fuel oil)					
Relative Weight of Imports and Exports (by volume)					
Imports as a share of domestic consumption (%)		24,5%	Exports as a share of domestic production (%)		27%
Main Source of Imports (% of Trade Flows)					
Russia (34,2%) 	KSA (13,6%) 	UK (11,9%) 	US (6,4%) 	India (4,7%) 	
Summary					
<p>Refined petroleum products cover a range of products that are co-produced simultaneously in the same refinery. The refinery industry has few substitutes in the existing market structure, with liquid hydrocarbons originating from crude oil currently dominating transport fuels. However, due to expected megatrends in the next decades in the area of transport, the refining sector is set to face an important transformation and a significant decline in European traditional transport fuel demand. When looking at individual fuel products, the EU has an important gasoline surplus that is exported to other regions and a large deficit in diesel and kerosene products that are imported from other regions. EU refiners are thus subject to competition in both their domestic and export markets. When both the production and use of fuels are considered, emissions incurred during the refining process account for about 8-10% of the total, while the majority (80%) of emissions occur during their use phase. Since energy can equate to more than 50% of their operating costs, EU refineries have continued over the years to invest in energy efficiency to stay competitive. As a result, EU refineries are on average amongst the most efficient in the world. That said, both energy efficiency and CO2 performance vary per individual refinery (whether in Europe or in other regions).</p>					

¹¹⁵ Data for production in EU27 in 2018 from Eurostat 'Supply, transformation and consumption of oil and petroleum products' dataset; data for 2018 global production from 'FuelsEurope Statistical Report 2020'.

¹¹⁶ 'Mainstream' refineries are those processing mainly crude oil to produce more than 40% light products, and which are applying for the Refinery Product Benchmark. Of the 82, 5 announced closures in 2020.

¹¹⁷ Number of installations in ETS Union Registry with main activity code '21 - Refining of mineral oil'. EU. 2019. Compliance data for 2019. ETS Union Registry. Accessed at https://ec.europa.eu/clima/sites/default/files/ets/registry/docs/compliance_2019_code_en.xlsx

¹¹⁸ Data for imports to the EU27 for 2018 from Eurostat, 'Imports of oil and petroleum products by partner country' [nrg_ti_oil] dataset. Data for exports from the EU27 for 2018 from Eurostat, 'Exports of oil and petroleum products by partner country' [nrg_te_oil] dataset.

3.8.1 Market Structure

The refining industry's product categories encompass a wide range of products: LPG, aviation gasoline; motor gasoline; gasoline type jet fuel; naphtha, aromatics, and olefins; white and industrial spirit; kerosene; diesel; heating gas-oil; marine gasoil; lubricants; heavy fuel oils. A refinery is a co-production process, with a range of refined petroleum products co-produced simultaneously in the same facility. Refiners have limited flexibility on the proportion of the different products they produce. This means that to deliver the product that is most in demand, refineries may create oversupply of other products. The average refinery size in Europe is ~160 kbbbl/d (1000 barrels per day) capacity.

The majority of refined petroleum products are sold directly to end-users, often through the marketing branch of the producing company or other private distributors. Indeed, sales to end consumers represent ~75% of the refineries' output, with end consumers being cars and trucks at the pump filling station (gasoline and diesel), air companies (jet fuel) and ship operators (bunker fuels). For the remaining production, sales are made to car manufacturers and retailers (lubricants), civil work (bitumen), petrochemicals (naphtha, aromatics, olefins), manufacturing industries (special fluids).

The refinery industry has few substitutes in the existing market structure. Transport fuels for example are currently dominated by liquid hydrocarbons originating from crude oil (94%). About 65% of the crude oil processed in EU refineries is transformed into transport fuels.¹¹⁹ However, the sector is expected to face an important transformation due to megatrends expected in the next decades in the area of transport: stricter regulations; new mobility schemes and transport modes; new technologies and new sources of energy for transport, that will contribute to reducing the carbon intensity of transport (Well to Wheel). Indeed, the EU demand for petroleum products is on a continuous decline (demand forecasted to decline by 10% between 2017 and 2030, and between 33% and 56% between 2016 and 2040).¹²⁰ The overall improvement in transport efficiencies - in particular via improved vehicle and engine technologies, the strengthening of regulation (review of the renewable energy directive, the review of light duty CO2 emission standards, the imminent introduction of heavy duty CO2

¹¹⁹ About 10% goes to petrochemical feedstocks; and about 25% is employed for other products. See: FuelsEurope (2018), Vision 2050: a pathway for the evolution of the refining industry and liquid fuels.

¹²⁰ IEA WEO 2017

emissions standards, the urban air quality concerns), the partial electrification of the fleet and low GDP growth, are all contributing to the decline in European transport fuel demand.

The potential mid to long-term future substitutes to fossil fuels include: electricity; (bio)gas; liquid (advanced) biofuels; e-fuels and hydrogen, some of which may also potentially be produced by other sectors. However, the latter might struggle to bring the scale that refineries as main suppliers can cost effectively deliver in particular because of the infrastructures that are needed and already exist.

In the EU, the refinery sector counted 82 ‘mainstream’¹²¹ refinery sub-installations in operation in 2016-2017. Out of these, five announced closures in 2020.¹²² These sub-installations are owned and/or operated by 42 different private companies from the EU27, and Norway.¹²³ These companies are a mix of multinationals and local operators. Typically, refineries are owned by private companies having trading companies for the purchase of feedstocks and sale of their products.

The sector is mature in the EU, and in spite of refinery closures and decreasing demand, the sector has kept investing in its remaining refineries in order to improve their competitiveness (rather than to increase capacity) via energy efficiency improvements, and to develop a refinery configuration better adapted to market demand (cleaner fuels, less heavy fuel oil, diesel-gasoline split). Refining is a capital-intensive industry with variable and volatile gross margin due to price movements in the crude and oil product markets, which is not under the control of refinery plants. The sector is characterised by high vertical integration, with the majority of the companies having upstream and downstream activities (supply & distribution). What is more, some of the refineries are integrated or directly connected with petrochemical industries.

The bulk of refined products are globally traded commodities with transparent pricing quoted at major regional refining hubs. Examples include Rotterdam in Northwest Europe, Mediterranean basin, the US Gulf Coast, and Singapore. The price of individual oil products, such

¹²¹ ‘Mainstream’ refineries are those processing mainly crude oil to produce more than 40% light products. The oil refineries benchmark for the granting of free CO₂ emission allowances under the EU ETS is based on the 10% most efficient mainstream refineries in the sector. A handful of additional, mainly small sites that perform specialised functions (mostly bitumen and lube oil manufacture), are designated as ‘atypical’ and receive free allowances according to the fuel and heat benchmarks defined by the European Commission.

¹²² Naantali (NESTE), Grandpuits (Total), Sisak (INA), Rotterdam (Gunvor), Porto (Galp).

¹²³ With only one exemption of Equinor which is state owned

as gasoline and diesel, responds to the supply and demand balance for that particular product. Prices in different countries and regions are generally set by reference to the nearest refining hub and linked to the cost of transporting the products between locations (which occurs at large scale, and hence at relatively low cost). Price dislocations between regions occur due to sudden changes in supply or demand in a given region, but these are only temporary in nature, lasting until the global supply chain reacts to close price arbitrages.

Another consideration for the sector is the very different economic scheme under which refiners in the EU operate when compared to refineries owned by national oil companies (e.g. in the Middle East). The latter have integrated operations in both oil production and refining, and see refining as diversification means that allows them to secure outlet of their crude production. The cost of crude for refiners in the Middle East are much lower compared to the price that EU refiners have to pay.

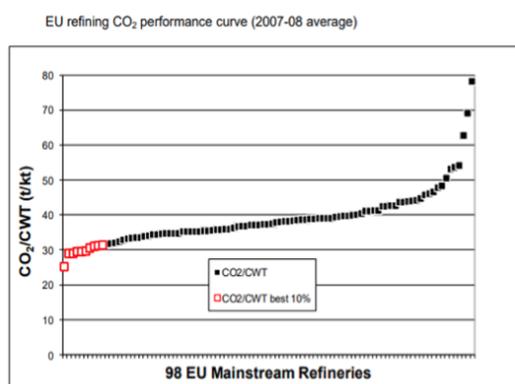
3.8.2 Environmental Considerations

CO₂ performance and energy efficiency vary per individual refinery, both in Europe and globally. The EU refining sector faces high energy costs, supplemented by energy taxes and CO₂ costs. Since energy can equate to more than 50% of operating costs, EU refineries have continued over the years to invest in energy efficiency to stay competitive. As a result, EU refineries are on average amongst the most efficient in the world, bettered only by the new super scale Asian export refineries.¹²⁴ In order to assess the emission performance of EU refineries, a method has been developed for the ETS Phase III using the 'CO₂ Weighted Tonne' (CWT) methodology also referred to as the capacity-weighted tonne¹²⁵. The graph at the left-hand side depicts the CO₂ performance spread of 98 mainstream refineries in the EU (2007-2008 data). The data shows that there are differences on the refineries' carbon intensity, based on how refineries have been built and maintained, the adequacy of the refinery, the crude quality used, and the energy efficiency of the refinery. Based on this methodology, it would be possible to compare performance of refineries in the EU and in exporting countries in terms of total CO₂ emissions related to the processing of any feedstock (irrespective of the specific products produced). CBAM, however, would require estimating CO₂ emissions associated with production of individual oil products, a challenging task inasmuch as these are produced simultaneously

¹²⁴ p.18, Concawe (2019), CO₂ reduction technologies. Opportunities within the EU refining system (2030/2050). Qualitative & Quantitative assessment for the production of conventional fossil fuels (Scope 1 & 2), Concawe report no. 8/19.

¹²⁵ For the methodology see: Concawe (2012), Developing a methodology for an EU refining industry CO₂ emissions benchmark, Concawe report no. 9/12

through a combination of interrelated processes. Notwithstanding, for the EU refining sector as a whole, the JEC consortium (JRC-Eucar-Concawe) has validated Concawe’s methodology which modelled the EU refining sector to generate a set of CO₂ intensities for specific products, as depicted in the table at the right-hand side¹²⁶. One option could be to conduct similar studies for the refining sectors in exporting countries before a comparison of the CO₂ performance of specific products would be difficult but possible. Another and easier option would be to apply the EU values on the imported product for the sake of simplicity and applicability. In the absence of such studies, Concawe is in the process of developing suitable methodologies that will allow to calculate the CO₂ emitted during the manufacturing phase of imported products.



Source: Concawe (2012), *Developing a methodology for an EU refining industry CO₂ emissions benchmark*, Concawe report no. 9/12, fig. 3, p.16

Total CO₂ emissions and intensities associated with selected EU refining final products

Product	Total emissions allocated to each product (Mt/a CO ₂)	Marginal emission intensities per tonne of product (tCO ₂ /t)
Gasoline	29.9	0.24
Kerosene	15	0.26
Diesel fuel	64.9	0.31

Source: Concawe (2017), *Estimating the marginal CO₂ intensities of EU refinery products*, Concawe report n° 1/17, table 2, p. 7

Refining is characterized by exchangeability between fuel and electricity, whereby either fuel or electricity can be used to produce heat or mechanical energy for the production of an equivalent product¹²⁷. Thus, both direct and indirect emissions are relevant for the sector. In the EU, the share of on-site / off-site electricity generation is about 50-50. Almost all on-site electricity generation is based on natural gas, with near zero fuel oil-based generation.

When both the production and use of finished refinery fuels is considered (well-to-wheel life cycle), the majority (80%) of emissions occur during their use phase i.e. when they are

¹²⁶ For more on the model and results see: Concawe (2017), *Estimating the marginal CO₂ intensities of EU refinery products*, Concawe report n° 1/17

¹²⁷ Moreover, “exchangeability” of electricity is applicable to refineries under the EU ETS, i.e. refiners pay CO₂ costs for both on site generation and bought electricity.

combusted (Scope 3 emissions). Emissions incurred during the refining process account for about 8-10% of the total. Nonetheless, emissions from the refining process itself could be potentially halved through three key pathways: 1) energy efficiency; 2) carbon capture (after 2030); 3) use of low carbon feedstocks (e.g. low carbon hydrogen).

3.8.3 Trade Patterns

Regarding general trade flows, the majority of the production from EU refiners are traded within Europe. The ratio of products exported was about 27% of EU production in 2018, while the ratio of products imported was about 24% of EU consumption (for a sub-set of five key products: naphtha, motor gasoline, kerosene-type jet fuel, road diesel, and heavy fuel oil).

European refiners are subject to competition from refiners from other non-EU regions manufacturing the same products. As an example, the EU has a gasoline surplus (~50Mt), which is exported to other regions, mainly to North America, West Africa and Asia. At the same time, the EU has a large deficit in diesel and kerosene, so these products are imported from other regions, including Russia, the US, Asia and the Middle East. Thus, EU refiners are subject to competition in both their domestic and export markets from refiners in those other regions.

With increasing prices of allowances under the EU ETS, there is an increasing risk of carbon leakage if international competitors are not subject to carbon regulations. As a case in point, trade intensity of the EU refining sector has increased from 16.4% (2014 CL list) to 25,8% (2018 CL list). This is on top of EU refinery economics being weakened by external factors such as world GDP growth, crude oil prices, new-built refineries in developing countries, product demand, etc.

3.8.4 Other considerations

Looking at countries of origin, Russia accounted for about 34% of total imports and the Kingdom of Saudi Arabia (KSA) for close to 14%, or for about 8,5% and 3,5% respectively of EU consumption. Russia is the EU's fifth largest trading partner and the EU is Russia's largest trading partner¹²⁸. In 2019, Russia was the origin of about 40% of EU imports of gas and 27% of EU imports of oil. Due to the large value of these imports, EU's trade deficit with Russia (€ 57 billion in 2019) is only second to EU's trade deficit with China. The Gulf countries such as the KSA represent also an important region for the EU from a trade point of view. However, the trade

¹²⁸ European Commission webpage on EU-Russia trade <https://ec.europa.eu/trade/policy/countries-and-regions/countries/russia/>

balance is the opposite, with the Gulf countries being the EU's fourth largest export market in 2016, generating a significant trade surplus for the EU¹²⁹.

Dependence becomes an issue when resources are highly concentrated. Upstream, crude oil is highly concentrated in the US, Russia and OPEC countries, however there is relatively less concentration on the refined products market. In oil producing countries such as in the KSA, there has been a diversification of the industry in recent years, with the addition of refining and petrochemicals capacities, driven partly by employment creation policies and as a means to capturing more value from oil. Exports in refined products from these countries are a substantial part of GDP but not as important as exports in crude oil.

One can conclude that the countries that would be affected by a CBAM relative to this sector are significant trading partners of the EU, are all part of the G20 and carry a significant clout in international trade and in international affairs more broadly.

3.8.5 Implications for CBAM Design

Taking into consideration its structure and exposure to carbon leakage, the refinery sector could be considered as a good candidate for coverage CBAM. The EU is a net importer of jet fuel and diesel, two of the sector's products that could in priority be good candidates for early inclusion in a CBAM regime.

Although refined petroleum products compete with few substitutes in the existing market structure, the sector is expected to face an important transformation over the next decades. Refining can make a significant contribution to the net-zero carbon economy in 2050 [See [Clean Fuels for All campaign](#)] by moving into the production of low and zero carbon fuels/products which will require tremendous investments and carbon leakage protection throughout the transition. Emerging renewable and low-carbon transport fuel substitutes include electricity; (bio)gas; liquid (advanced) biofuels; e-fuels and hydrogen, that could also be produced by other

¹²⁹ Total trade in goods in 2017 between the EU and the six member countries of the Gulf Cooperation Council (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the UAE) amounted to €143.7 billion. In 2017, EU exports to the GCC amounted to €99.8 billion. In the meantime, EU imports from the GCC accounted for only €43.8 billion, generating a significant trade surplus for the EU. Source: European Commission webpage on EU-GCC trade <https://ec.europa.eu/trade/policy/countries-and-regions/regions/gulf-region/>

sectors. Arguably, if refined petroleum products are covered by a CBAM, so should these emerging substitutes to avoid market distortion and the creation of an un-level playing field.

Refining is characterized by exchangeability between fuel and electricity. Therefore, both direct and indirect emissions would ideally need to be covered in the adjustment for the sector. There is some potential for resource shuffling in fuels¹³⁰, that would argue against allowing foreign producers to challenge any default values for embodied carbon. Another challenge for the sector is the estimation of CO2 emissions associated with the production of individual oil products, as these are produced simultaneously through a combination of interrelated processes. A “fair” comparison would be done through the application of the CO2/CWT performance related methodology.

Finally, the EU is a net exporter of gasoline and EU refiners are subject to competition in export markets from refiners in other regions. In designing a CBAM against the potential deterioration of the competitiveness of the EU refining industry against competitors from regions with lower climate ambitions, not only imports but also both EU manufactured products exported outside the EU as well as products along the upstream and downstream value and supply chains may have to be covered.

¹³⁰ Importers may redirect products produced by the most recent and efficient refineries in the EU while redirect more carbon intensive products elsewhere. Very large and effective refineries recently put in operation are located in the Middle-East and they are designed for exports, they have full flexibility to make one or another type of the product to sell to other markets and adapt to the needs/policies of the other markets, either east or west.

4 Cross-Cutting Analysis

The in-depth analysis of eight energy-intensive and trade-exposed sectors conducted in this report reveals a number of overarching patterns that are of direct relevance for the design and implementation of a CBAM. The survey has also allowed identification of certain particularities that are unique to a subset or individual sectors, and which raise questions about the feasibility of applying a single CBAM design across all sectors, or indeed the viability of relying on a CBAM as the sole instrument to mitigate the concerns that are prompting consideration of this policy instrument in the first place.

Overall, therefore, the sectoral survey suggests that specific challenges identified at the sectoral level (see below, Section 4.2) are likely to require specific CBAM design features or, in some cases, may necessitate recourse to other instruments altogether. Ensuring the effectiveness of a CBAM may therefore require an instrument design that differentiates between sectors, covers only some sectors, or is accompanied by additional instruments to address certain sectoral features. This will have to be balanced against the complexity of implementing different approaches to CBAM. At the same time, the survey underscores the growing pressures that can contribute to emissions leakage and competitive issues, and merit attention in the debate about appropriate policy responses. Across virtually all sectors, competition in the global market for commodities that these sectors supply has become more aggressive in recent years due to a variety of factors.

Rapid growth in foreign production capacities and output has seen European producers lose market share both in the domestic and in foreign markets. In many sectors, such as steel, aluminium, and refined petroleum products, this situation is exacerbated as largely or fully privatized European producers compete with foreign producers which, in turn, are often state-owned and benefit from strategic government support. A sharp increase in trade defence measures by the European Union against several trade partners illustrates the aggressive levels of competition that already characterise trade in relevant products.

Similarly, electricity imports into the EU are set to grow considerably in the near future as interconnection capacities expand and demand rapidly grows in the EU. Electricity is only the most obvious example of local changes in competition and trade patterns. In many other sectors, leakage effects along the external borders of the EU (and, more locally, in coastal Member States with large ports) are far more evident than they are across Europe as a whole, underscoring the need to also apply a regional focus and not rely purely on EU average data.

While these trends in international competition are not all related to EU producers bearing carbon costs, they create a context in which production cost increases due to climate policies

cannot be as easily absorbed and can therefore be expected to have a stronger impact; that, in turn, makes the search for effective measures against emissions leakage more urgent.

Although available, and in many cases at early stages of commercialization, technological options for deep decarbonization are still associated with high cost in most sectors, and that will add to the pressures stemming from the projected increase in the speed and scale of decarbonisation under the European Green Deal. Already, the most recent 18 months have evidenced the upward pressure this political commitment exerts on carbon prices in the EU ETS.

4.1 Cross-Cutting Design Considerations

For the specific design choices that need to be made before a CBAM can be operationalized, the sectoral analysis offers important insights on a variety of parameters, including trade flows, product coverage across the value chain, and coverage of emissions.

A majority of sectors, including chemicals, fertilizers, pulp, non-ferrous metals and certain refined petroleum products rely on or, derive a significant share of revenue from exports, and therefore have an interest in a policy response to carbon leakage that addresses the impacts of rising carbon costs on their position in global markets. A CBAM that only covers imports threatens to weaken the position of domestic producers in foreign markets, and that is not merely an economic concern: given the relative carbon intensities of EU and foreign production in many sectors, loss of global market share would, in many cases, result in a net increase in global emissions. In order to address this export-related dimension of leakage, some provision for exports – whether as part of a CBAM design or a separate policy mechanism – is likely to be necessary.

Many sectors, including chemicals, non-ferrous metals, and pulp and paper, have complex downstream value chains in which trading is dominated by semi-finished and finished products. Where these products contain a high share of the carbon-intensive raw material and the processing results in limited value-added, such as flat and long steel products, or flat rolled and extruded aluminium products, exclusion from the coverage of a CBAM may render them vulnerable to substitution by imported products at the same level in the value chain. Since the direct (Scope 1) and energy-related indirect (Scope 2) emissions from producing such semi-finished and finished products are often moderate relative to value added, their inclusion in a CBAM would have to reflect emissions from the upstream production of the intermediate goods incorporated in such products (Scope 3 emissions), such as the emissions embodied in the steel used as a raw material for pipes.

But adjustment for the carbon costs associated with direct and indirect emissions may not be sufficient under a CBAM to address leakage concern in some sectors. For sectors with high

present or increased future electricity intensity, additional safeguards will need to be considered for increases in the cost of electricity consumed that are only indirectly related to the emissions intensity of that electricity. Because of the way electricity prices are determined in the European wholesale power market, based on the variable cost of the marginal generating unit in the merit order dispatched to meet demand, any carbon cost borne by that marginal unit will also be reflected in the power price paid for renewable energy if that marginal unit is based on coal or natural gas generation. Hence, the carbon costs associated with electricity are decoupled from the indirect physical emissions of electricity intensive producers. Some sectors – such as ferrous and non-ferrous metals, chemicals, and pulp and paper – are already affected by this dynamic, yet in many other sectors the pathway to deep decarbonisation will rely on electrification (e.g. for process heat), meaning that this challenge will become more pronounced over time.

In most regional power markets in Europe, the marginal source of electricity generation is still carbon emitting, and interconnection of these markets will result in pass-through of some or all of the carbon cost borne by the marginal generating units between markets, adding a degree of complexity in identifying the exact effect of carbon pricing on electricity prices of a particular consumer. A measure other than a CBAM may be needed to effectively address this aspect.

Finally, the identification of major trading partners for the sectors included in this survey show that crediting for climate policies in place in the country of origin of imported products will be far from straightforward. The largest EU trading partners in sectors such as cement (Turkey), chemicals and pulp and paper (United States), or ferrous metals and refined petroleum products (Russia), have not instituted a national carbon price, and even where carbon pricing has been, or may soon be introduced, price levels are likely to be lower, while policy design (including aspects such as free allocation, or price formation in the electricity market) may affect whether and to what degree the carbon price is passed through to foreign producers. That does not equate to a complete absence of carbon costs in relevant sectors, however: as the example of the United States shows, producers in these countries may face a variety of policy constraints on their emissions, from subnational carbon pricing to non-pricing instruments such as performance standards.

A common feature in jurisdictions without a uniform, explicit carbon price is vast heterogeneity of the carbon costs faced by local producers, incurring substantial methodological challenges for any policy design that seeks to credit foreign policy efforts. Altogether ignoring regionally divergent or non-pricing policies, in turn, is likely to prompt political contestation and may also be criticised as an attempt to interfere in the policy choices of sovereign jurisdictions in contravention of the spirit of the Paris Agreement. Other solutions, such as exempting countries

that have demonstrated a “comparable level of effort”, likewise raise complex methodological, legal, and political challenges.

4.2 Sector-Specific Design Considerations

As mentioned earlier, important considerations for CBAM design apply to a subset of sectors only. In several sectors, for instance, such as refined petroleum products and non-ferrous metals, product pricing is determined at the global or regional level through a transparent reference price or price benchmark.

In the case of many base metals, the reference price is set globally at the London Metals Exchange, whereas prices for refined petroleum products are quoted at major regional refining hubs. As long as climate policy efforts in the relevant sectors remain uneven across jurisdictions, a uniform and transparent commodity price at the global level virtually eliminates the ability of producers to pass through carbon costs. Similarly, in sectors such as steel, competitive pressures exacerbated by unfair trade practices, such as dumping and politically motivated and supported production overcapacities, also narrow the ability of EU producers to pass through costs without risk of losing market shares.

In other sectors, by contrast, such as chemicals or pulp and paper, a CBAM is likely to result in carbon cost pass-through to downstream producers via the price of input (intermediate) goods. Although that may seem *prima facie* desirable from a climate policy perspective, since it extends the behavioural signal induced by the carbon price through the value chain, it can shift leakage risks further downstream that may, in turn, necessitate safeguard measures such as inclusion of downstream products in the scope of the CBAM.

Resource shuffling is another challenge for the effective implementation of a future CBAM, but has differentiated urgency across sectors. It describes a situation in which imposition of the CBAM to imports will have no tangible effect on trade volumes or aggregate emission levels because foreign producers are able to substitute low-carbon products for exported carbon-intensive products. Some sectors that are likely to see more pronounced risks of resource shuffling include electricity as well as ferrous and non-ferrous metals.

It could, however, also be argued that a CBAM should not serve to restrict the flexibility of foreign producers to decide which products to export to the EU and which to sell in their domestic or other foreign markets – they are only meant to level the playing field on the cost of carbon embedded in products sold in the EU, not lead to a change in overall structure of foreign production. Likewise, for domestic policy choices, the NDCs are meant to be nationally determined and measures put in place to “nudge” other Parties to modify their NDCs in line with that of the EU may not be within the spirit of the Agreement. Such arguments are likely to be

voiced by trade partners objecting to the application of a CBAM, and therefore need to be anticipated already in its design and implementation.

However, there is also the counter-argument that resource shuffling threatens to undermine the intended effects of the CBAM: if current leakage safeguards are replaced with a CBAM, yet resource shuffling enables foreign products to lower or avoid any carbon cost when entering the EU, the CBAM will not have contributed to levelling the playing field for EU producers and merely shifted trade patterns as European industry continues to face mounting carbon costs which will not be borne by the sector as a whole in other countries.

In the end it boils down to what is the objective or objectives of a EU CBAM.

In several sectors, such as non-ferrous metals, foreign production capacities are such that imports to the EU could be readily substituted with low- or zero carbon products from the same countries; for instance, China has enough aluminium smelting capacity powered with low-carbon hydroelectric power to meet the entire European demand for Chinese aluminium, whereas the *average* carbon intensity of aluminium production in the country is significantly higher than that in Europe. As that example shows, resource shuffling can only occur if the CBAM is imposed on the actual measured, reported and verified emissions embodied at the level of the actual product or facility, rather than on the basis of a reference or default value, such as a country's average carbon intensity.

Several products compete closely with each other in important market segments, for instance ferrous and non-ferrous metals, paper and board, and plastics in the market for packaging. Imposing a CBAM only on some of these products and not the others could result in arbitrary substitution effects. The final effects would depend among other things on whether free allocation was terminated for activities covered by CBAM, or continued, and whether the CBAM covered downstream goods or not. Ideally, therefore, such competing products should be bundled in the coverage of a CBAM to avoid such arbitrary substitution effects.

In a similar vein the fuels-electricity relationship plays out in terms of emissions scope. Including Scope 2 emissions in the emissions scope of the CBAM creates incentives to switch from fuel as an input to electricity as an input, and not including them creates incentives to switch from electricity to fuel. The mechanism here is that if Scope 2 is not included, then users of electricity bear the indirect costs of electricity's embodied emissions but receive no commensurate protection.

Finally, some sectoral particularities are only relevant for very specific product categories. Determining the emissions intensity of refined petroleum products, for instance, is subject to considerable methodological challenges even for domestic production, and these challenges are

likely to be even more pronounced when it comes to determining the emissions intensity of imported refined petroleum products. Alternative administratively feasible, enforceable, suitable methodologies are currently looked at within the sector at stake. Such methodological challenges may have a bearing on the decision on which sectors to include, at least in an initial learning phase of a CBAM.

Another example is ferrous and, to a lesser extent, non-ferrous metals, where emissions intensities vary significantly between the primary (virgin) and secondary (recycled) production process. While both production processes need to be covered – on its own, the secondary production process, although less carbon intensive, could not meet demand nor allow ensuring certain product characteristics – the sizeable process-related difference in emissions intensities requires consideration of different CBAM parameters for each process.

Table: Summary of Sectoral Particularities¹³¹

Sector Feature	Cement	Ferrous Metals	Non-Ferrous Metals	Chemicals (Plastics)	Fertilizers	Pulp and Paper	Refined Petroleum Products	Electricity
Downstream Vulnerability¹³²	Low	High	High	High	Low	Medium	Low	Low
Share of Exports¹³³	Medium	Medium	Medium	High	Medium	Medium	Medium	Low
Indirect Carbon Cost¹³⁴	Medium	Medium/High ¹³⁵	High	Medium	Low (varied)	Medium	Medium	Low

¹³¹ The assessment in this table is meant as a heuristic guideline and not based on a uniform set of quantified metrics or criteria; instead, it is based on an overall judgment reached in discussions among the authors and informed by communications with representatives of the sectors and the available literature.

¹³² Downstream vulnerability refers to the risk of an CBAM applied to upstream production shifting competitive pressure and leakage further downstream in the value chain (e.g. imports of raw materials covered by a CBAM decline, but imports of products not covered by a CBAM and manufactured from those raw materials increase commensurately). See also Section 4.1.

¹³³ Based on the share of EU exports relative to overall EU production (as indicated, in %, in the sector profiles), not absolute quantities or value.

¹³⁴ Set to expand across further sectors as electrification of process heat and other processes is increasingly harnessed as a pathway towards deep decarbonization.

¹³⁵ “High” for secondary steel production through the EAF process.

Reference Price¹³⁶	Low	Medium	High	Low	Medium	Low	High	Low
Data Challenges	Low	Medium	Medium	High	Medium	Medium	Medium/High	Medium
Resource Shuffling Risk	Low/Medium	Medium/High	High	Medium	Medium	Medium	Medium	High
Competing Substitutes	Ferrous Metals	Cement, Non-ferrous metals, Plastics	Steel, Plastics, Paper	Non-Ferrous Metals, Pulp and Paper	None	Steel, Plastics	Electricity and low-carbon fuels	Fuels

¹³⁶ “Reference price” refers to the existence of a global reference price, such as the price for base metals published by the London Metals Exchange (LME), see Section 4.2.

5 Conclusions

This report is part of a larger body of work on CBAM undertaken by ERCST. It builds on our earlier work that defined and explored the design elements possible for a CBAM, going further to assess the implications for those design elements of the very different characteristics found in eight of the candidate sectors.

Our deep dive into the sectors is revealing. As a starting point we note that across virtually all sectors, competition in the global market for commodities that these sectors supply has become considerably more aggressive in recent years, for reasons not related to climate policy only, but where climate change policy nonetheless plays an increasing role (when EUA prices climb from 5 to 41 Euros).

As well, all the sectors examined here face a future in which EU climate policy looks likely to exacerbate those global challenges. These are, after all, classic energy-intensive trade-exposed sectors. All of them, to varying extents, face the need of many billions of Euros of investment over the coming decades, and the challenge is to ensure that investment actually creates ambitious reductions in European emissions without simply transferring those emissions abroad, as well as ensuring a decarbonized but industrial Europe.

At that point, however, the similarity across sectors begins to erode. The specific challenges identified at the sectoral level are likely to require specific CBAM design that differentiates between them or, in some cases, may necessitate recourse to other instruments to complement what a CBAM can do.

Different CBAM designs for different sectors is one potential approach but the challenges of putting in place such a complex quilt of approaches is not what was envisaged when a BCA was first considered and may become difficult to understand, administer and “sell”, domestically and internationally. As discussed in the previous section, those challenges include the fact that many sectors export their products beyond the EU. Should a CBAM be meant to replace free allocation as a complement to the ETS, then those sectors with significant exports will need some form of protection that ensures that the result is not simply loss of global market share and leakage to other jurisdictions. Yet we know there are legal challenges involved with either export coverage by a CBAM or implementing a CBAM while retaining free allocation.

Several sectors are characterized by high indirect carbon emissions, and for these the ideal CBAM would cover both direct emissions and Scope 2. Moreover, pricing of electricity in the EU is such that some facilities in these sectors experience the costs that the ETS imposes on producers of electricity, even beyond those that would be covered by a CBAM that included

their Scope 2 emissions. This implies the need for a mechanism like the existing compensation for indirect costs, either as part of a CBAM or as a complementary instrument.

Some sectors have particularly long and complex downstream value chains, and for these the challenge is to find a CBAM that both covers downstream producers and includes some Scope 3 emissions – those embodied in the input goods they purchase from emissions-intensive upstream facilities. But it is a challenge to decide at what point in the sectoral value chains that coverage should stop; at what precise point does the risk of leakage recede enough—diluted by the increasing ratio of value-added to carbon cost, and the fact that heterogenous final products compete on more than just price—that we can say the CBAM is no longer needed?

As a practical matter, these sector-specific challenges bear on the question of whether the CBAM should be implemented initially as a sort of pilot project with limited sectoral participation, and if so which sectors should be in and which out. We have noted that this question needs to be informed by the potential for substitution across the candidate sectors. And we note further that it is critical for all sectors to know how and when they will participate in a CBAM, not just in the short term. The significant investment needs over the coming decades need to be underlaid by some knowledge of the conditions of that investment.

Ultimately, the needs for coverage and administrative challenges makes this instrument one that needs to be approached with great caution as we move from exploration to implementation, and its relationship with existing approaches to carbon leakage and competitiveness. A CBAM may complement or replace free allocation, depending on the design and political decisions, without running the risk of providing double-protection.

These considerations will feed directly into our ongoing work, which turns next to more concrete recommendations for the shape of a CBAM and complementary instruments that can rise to those challenges and support the critically important effort of EU climate ambition.

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