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Price pass-through of CO_2 costs

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Abstract

The price pass-through of CO_2 costs was analysed for HRC and PE/PP products as parts of a BEV. It was revealed that the feasibility of transferring these costs hinges on a company's ability to dictate prices, either as a significant player in international markets or through bilateral agreements. While the data and information gathered shed light on the complexity of business relationships and markets, it unequivocally demonstrates that the question of price pass-through is far from being answered straightforward. Low transparency about various business relations and markets, lack of information on specific production volumes, inputs, and current cost and pricing data were identified as critical hindrances to assessing the pass-through of prices, despite the existence of scientific concepts. Within the industry, a few companies may possess a strong foothold in the global market and be equipped to navigate elevated costs without external intervention, whereas others may lack the means to offset cost increases due to CO_2 prices. Policymakers are thus faced with the challenge of formulating targeted policies for less competitive companies and industries expected to lose market shares due to CO_2 pricing, while refraining from interfering with those capable of robust market competition. In essence, the domestic imposition of CO_2 pricing poses a significant threat to the price competitiveness of the domestic carbon-intensive industry. A well-designed CBAM is imperative, yet its effectiveness on global prices also hinges on whether global producers are subject to CO_2 emission costs. Should global producers remain unaffected by such expenses, many European producers are likely to encounter a general cost disadvantage when exporting to the international market.

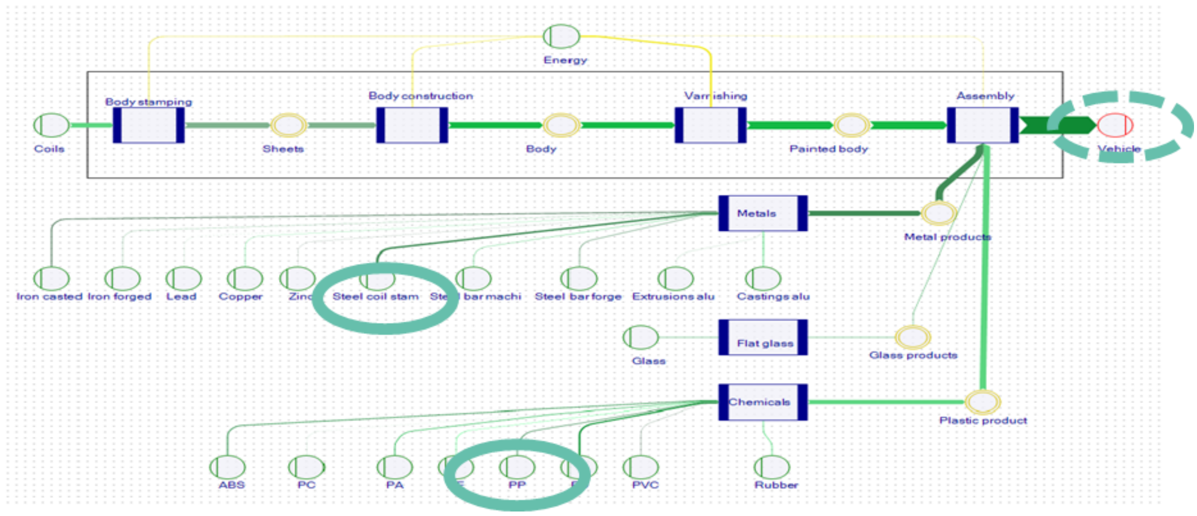
Keywords: competitiveness, CO_2 prices, chemical and steal industry

Contents

1 Introduction

In the light of the decarbonisation of our economy and the tightening availability of emission allowances within the ETS, pressure to decarbonise the energy- and carbon-intensive industry is rising. Turning the production and consumption of CO_2-intensive goods into a material-efficient and circular economy contributes significantly to the objective of a CO_2-neutral economy, as set out in the long-term vision proposed by the European Commission. However, also concerns arise regarding the competitiveness of affected industries, their profitability and their potential to pass through higher costs resulting from increasing CO_2 prices to their customers, be it business-to-business or business to final consumer. This study focuses on steel, aluminium, chemical and refinery products that are covered by the EU emission trading system. Further, within this study, the CO_2 emissions and cost shares of different intermediate products along the value chains have been assessed for automobiles (both with internal combustion and electric) and the plastic products polyethylene (PE) and polypropylene (PP). Regarding the mass fractions, steel accounts for 45%, aluminium for 17% and plastics for 12% of the total energy input (see section 3). The share of CO_2 emissions is 43% for steel, 22% for plastics, 10% for graphite and 6% for aluminium (see section 3). Given these shares and previous results of chapter 2 and 3, this analysis looks at steel and plastic products used in a BEV (electric car with battery). Within the metals needed for a BEV, hot rolled coil (HRC) plays a significant role, while within the plastic products polyethylene (PE) and polypropylene (PP) are important materials and included in relevant components of an automobile.

Figure 1: Value chain of automobile production



Source: UBA (2024), adjusted

Hot rolled coil is a flat steel product and has the largest volume share (of 54% in the EU in 2015) within this steel category (see UBA (2024)). Within this study, based on a general data compilation conducted and outlined in chapter 2, the assumption has been made that flat steel products can be assigned largely to the primary steel production route in the blast furnace (BF/BOF). This production route is significantly more energy- and emission-intensive than the secondary (predominantly scrap-based) production route in the electric arc furnace (EAF) that is used primarily in long steel products. Not considered in this study, but potentially relevant in the future, is the use of direct reduced iron (DRI) instead of scrap in the EAF, which could substitute for the primary production route in the future. Hot rolled coil can be used directly or can be further processed (e.g. cold rolling, galvanising and/or coating). The main demand for this product can be assigned to constructions and vehicles. In this report, we focus on the use of HRC in the production of an electric passenger car (BEV).

A large share of hot rolled coil is stamped at the manufacturer's site and a small share is also stamped for assembled components. The main application is the structure of the vehicle body (preassembly), which represents about 85% of the HRC material share in a BEV. Moreover, HRC is also used for doors, wheels and related components, dampers within the engine and gearbox as well as for the seats (VDI 10/2021, Automobil-Produktion 05/2021, Automobil-Industrie 11/2021).

Also polyethylene (PE) und polypropylene (PP) are products whose production processes are covered by the EU-ETS in the chemical industry. The precursor's ethylene and propylene are usually based on naphtha or other organic compounds from refineries that are transformed into steam-crackers (see our reports 2 and 3). The PE or PP polymers usually reach the processor in the form of plastic pellets, where they are mixed with additives (pigments, UV stabilisers, etc.) and transformed into products by plastic processing methods such as extrusion (continuous) or injection moulding (discontinuous). The energy requirement for plastics processing is significantly lower than that for the production of ethylene/propylene in the steam cracker in the upstream chain (approx. 3 MJ vs. 16.5 MJ/kg). Due to the EU plastic strategy, among other factors, recycled plastic will be increasingly used in the future, so that plastic products of the primary route as described here will become less needed. To what extent the use of recycled products is even feasible with high quality or safety-relevant products, such as e.g. bumpers in automobiles, is still unclear.

This report analyses the potential of CO_2-cost pass-through for hot rolled coil and PE/PP and their final cost share in BEV. The overarching objective is to contribute to a better understanding of potential price pass-through at this product level. Due to missing data on the actors, their shares along the value chain, and the specific quality requirements of intermediary products between PE/PP und HRC, the focus of this study is on the market of HRC and PE/PP products, and not on further intermediary markets.

This chapter first outlines the methodological approach, then analyses and outlines the market situation of HRC as well as for PE and PP products and of the BEV market. In the last sub-chapter, the potential of CO_2 cost pass-through for HRC as well as PE and PP products is assessed and conclusions are drawn.

2 Approach

In a competitive and well-functioning market, prices are the result of supply and demand. In case of an elastic demand for a certain product, any changes in prices might result in significant changes of the demanded quantity, while under an inelastic price-demand relation, the demanded quantity hardly changes. However, this is a theoretical situation, as such market outcome is only feasible under a situation in which all suppliers act in a similar way and the market is closed, i.e. no other suppliers have access to the market. Under competition and a global market, a few suppliers may be able to offer products at lower prices and thus push the more expensive suppliers out of the market. Therefore, the ability to pass through costs or prices to customers is discussed under the notion of competitiveness. Competitiveness could be referred to a country, a sector or company. For example, the OECD defines competitiveness as measure of a country's advantage or disadvantage in selling products in international markets (OECD statistic) while in business it is seen as the ability of a company to pre-empt the competitors in the same market. Further, another major differentiation is between the micro- and macroeconomic perspective (Delgado, Ketels, Porter, Stern 2012). Understanding of competitiveness at the macro-level refers to different aspects such as productivity or global sales. It is driven by ecological, social, distributional, technical indicators and capabilities and trust (Marginean 2006). For example, infrastructures (social, physical, financial), institutions (political, social, legal), resources (human, physical), policies (fiscal, monetary). In contrast, microeconomic aspects focus on certain characteristics of firms competing for market shares and profits under a given business environment. The characteristics include among others, strategies, organisation, structures, management, and of course the business environment, i.e. supply-chain, resource/input factors and demand conditions (Delgado, Ketels, Porter, Stern 2012). According to Porter (Porter, M.E., 2004), the competitiveness of a nation is founded on microeconomic factors, while conditions at the macro-level (political, legal, social, economic and institutional aspects) are necessary to ensure the enabling framework. Ongoing research examines the notion of competitiveness from a third perspective, the meso-level. It encompasses competitiveness of certain sectors that are affected by, for example, trade, regional resources, technical education and labour policies in the specific industrial areas. In general, in case of a competitive market, companies might face problems in passing through rising production costs. Analogous to competitiveness, the degree of competition in a market depends on its structure, size, number, and participants as well as the environment and context in which the company operates. These factors affect their ability to pass through costs while innovations could entail competitive advantages. Further, specific product features play also a role when rolling over costs.

Overall, development takes place at multi-levels that call for an understanding of the micro-meso-macro environment, as it reflects the interactions of actors with a subset of other agents of a system (Vlados, Chatzinikolaou, 2020). This broad understanding of competitiveness and factors shaping competition makes grasping and identifying key factors influencing the ability to pass-through costs very challenging. In the following, the main factors that affect the potential of rolling-over costs are outlined.

2.1 Competition

In business, two main types of competition are discussed, the price competition and quality competition. Recently, the concept of competition is extended by further aspects such as competition for social and ecological aspects (OECD 10/2013), which could be understood as quality competition in a broad sense. Under a pure price competition, cost advantages such as a high productivity or low input prices is key for succeeding in such the market; under international competition transport costs play also a role (Zweifel, Heller 1997). In a very competitive market, in economic theory called perfect competition, the market price is equal to the minimum average of total costs (fixed and variable costs). For a short period, the price could even fall below this threshold as long as it still covers the variable average of total costs. However, according to economic theory, a price below the average total costs leads to bankruptcy and, hence, market exit, as investments are not covered in the long-term. Further, under a theoretically pure price competition, the product is strictly homogeneous, i.e. products display the same characteristics and are fully comparable.

In contrast, a key characteristic of a quality competition is the difference in characteristics between products, i.e. they are not homogenous. This means they differ in quality and/or time of availability for consumption and supply for production, and/or are linked to a service. From an extended perspective on the above-mentioned competition, quality characteristics could also be environmental-friendly and socially fair production. However, to have a quality competition, the number of customers with differing preferences has to be large. Under a quality competition, different prices of the "product" exist and cost increases can be easier passed through than under a price competition. The product variety at the market can be captured by the existence of a large variety in prices, resulting from different type of customers with different quality requirements of the product, in potentially small or niche markets. The focus is on the competitiveness of Germany's industries.

For the assessment of the type of competition we look at:

- the types of customers in the hot rolled coil and PP/PE market as they might display different requirements regarding the characteristics of the product
- the exposure to international markets could be captured by the share of exports to and imports from countries outside the EU; it reveals whether the sector is exposed to international markets, and hence international competition
- the general degree of homogeneity of the product with respect to its material requirements and linked services
- the intensity of competition is based on the theoretical assumption that under perfect competition the market price equals the minimum average of the total costs and the marginal costs. The closer price and total average costs are, the stronger is the competition.

Table 1: Indicators displaying competition

Aspect	Description	Level	Indicator
Type of customers	Final consumer (B2C), producers or service providers (B2B), intermediate product within the integrated company (I)	Germany	Share of B2C, B2B, I
Exposure to global market	Share of EU external exports of German production(outside EU) Imports from outside the EU to domestic production or demand	Germany	% average value
Homogeneity	Existence of differentiating features of products (quality features)	Global, EU, Germany	Yes/no

Aspect	Description	Level	Indicator
Intensity of competition	Perfect competition: price = minimum average costs = marginal costs	Germany	Market price per unit to average costs

2.2 Market structure - supplier side

The intensity of competition depends on the market structure; this means its number of participants (suppliers), their size, and degree of horizontal (Clarkson, Miller 1982) and vertical integration (Chandler 1994). Further, market entry barriers such as economies of scale or scope or limited access to resources are means to reduce competition in markets and signal, if they are effective, a weak competition (Gilbert 1989, Bain 1968). In contrast, market exit barriers such as sunk costs or social restriction signal a competitive market in which over-capacities might exist. To assess the intensity of competition Katzenbach (1967) discussed the dynamics in revenues, or sales, and adjustments. To assess the market structure, we focus on the market, i.e. we look at the market size, number of market participants, market shares, market entries and exits, while integration of production is considered under the section "business environment".

- The size of the market does not necessarily report on the degree of competition, but it allows concluding what the potential influence of single producers is. Therefore, we derive information about the market size through the existence of international and/or regional market prices. We assume that, if a global or a large regional market exists, competition is strong.
- The market share is a very direct indicator revealing the potential influence of an actor on the market, and hence, on the market price.
- A more direct proxy for competition among suppliers is the number of suppliers, which in combination with the market size and shares provides information on the degree of competition.
- Another proxy for a high competition are the activities regarding market exits and market entries, showing whether market barriers exist or not. If no market barriers exist, we assume a strong competition.
- Regarding the rivalry, proxies are the emergence of a new industry with a few players (not relevant for HRC, PE and PP), and whether the dynamics in sales, i.e. changes in sales or revenues are large. If there is a high volatility in prices, we assume a high rivalry, and hence, competition.

Table 2: Market structure indicators - supplier side

Aspect	Description	Level	Indicator
Market size	Existence of a global market price, regional market prices, (e.g. EU, USA, China, ...)	Global, EU, national, local	€/t
Market participants	Number of suppliers and their size	Global, EU	Numbers
Market share	Share of top 5 suppliers Share and rank of top 5 German suppliers	Global, national	% of top 5 (global) % ranks (Germany) % export (Germany to global trade)

Aspect	Description	Level	Indicator
	Export share of producers in Germany to total global market		
Market entry, market exit	Number of market entries and/or exists	Global or EU	Number per year (or each 2, 5 or 10 years)
Intensity of rivalry	New industry? Dynamics and changes of sales or revenues?	Global Germany	Yes/no, examples Sales (€) or production (t) over time

2.3 Environment of business

Porter (1990) elaborated a model to analyse the competition businesses are facing, He identified five main factors that determine how successful and competitive a business might be. This includes pressure through new competitors, the existence of substitutes of the supplied products, strategies and structures of businesses such as degree of integration (horizontal (Clarkson, Miller 1982) and vertical (Chandler 1994)), market power of suppliers and customers, and intensity of rivalry. To further qualitatively evaluate the extent of competition, we include the environment of a business, and look at the degree of integration along the value chain. The vertical integration has an impact on the business environment as it changes the customers or suppliers of a company. Further, we account for the existence of substitutes, structure of the sales market and changes in sales. Since Schumpeter (1997) explained the competitiveness of a business by its innovation activities, we include innovations. According to him, firms conduct research and product development to improve their competitiveness and offer products differing in quality and prices. This approach is helpful to analyse the competitiveness of R&D-intensive companies and identify whether companies deal with new and qualitative differing products or with well-established and not R&D-intensive products offered in a price competitive market. Further, innovations enable firms to earn a temporary "monopoly rent", i.e. a high price, as long as no other competitor is able to offer a comparable innovation. Thus, we look also at potential product developments.

- The integration of producing units along the value chain within one corporation allows to pass through prices changes to the end of the "internal" final-product. This is a strong integration of production stages. A weak integration could be given by a strong contractual relationship but not ownership of production units. Examples of a weak integration are long-term partnerships or contracts. To what degree price adjustments are feasible in long-term contracts, depends on the contract agreement. For instance, the product price could be based on a global product market price index or production price index like in electricity contracts.
- Substitutes allow to replace materials that become scarce or too expensive. They allow companies to adjust to high production costs through using substitutes. If substitutes exist for potential customers of the HRC, PP or PE producers, passing through of higher prices is not possible.
- Competition in a market is driven by the number of suppliers and demanders. Thus, we include the number and size of existing customers. Furthermore, beyond the existing customer-supplier relationship in the automotive industry, the potential of alternative customers outside the automotive industry could mitigate potential market power and concentration at the demand side.

- Product innovations encompass incremental changes in products or in some of its features as well as new products that completely replace the former. They contribute to the development of substitutes.
- Process innovations refer to changes in the production process and might even entail changes in the feature of products, potentially resulting in to new substitutes or differentiations in product features.

Table 3: Indicators outlining the business environment

Aspect	Description	Level	Indicator
Integration	Type and degree of integration: producing unit is part of the internal value chain (vertically integrated in the corporation, I)? Long-term contracts (L)?	German companies	% of production/sales per type (I, L)
Substitutes	Potential substitution of product? Actual substitution Hypothetical substitution	Global	Yes/no Substitutes? Barriers (technical, economic…)
Sales market	Number and size of customer? Alternative customers, that could demand the product if sales to automobile customers decline?	Global	Number of customers Yes/no; brief description
Product innovation	Small improvements of products, new products or destructive innovations?	German companies	Yes/no
Process innovation	Small improvements, or new processes	German companies	Yes/no

2.4 Product features and other aspects

Based on strategic management approaches (Latuffe 2010), we select further indicators at the product level such as cost shares, types, prices and price-driven demand. Theoretically, further product features such as reliable supply, timely availability and sustainability might strengthen the competitiveness in a quality competition, but data on these features are not available. The Cross Border Adjustment Mechanisms (CBAM) is considered here as well. It is to note that data and indicators are rather limited, since hot rolled coil and PPE/PE pellets are not final but intermediate products, cost shares: cost shares are supposed to reveal how significant the different inputs are, and how they compare to prices at different markets price and sales data over time ideally disclose how sensitive demand might react to price changes. Data could encompass production and market prices or import volumes and values transport costs indicate potential additional costs in case the product is traded at international markets, the higher they are, the more they reduce a potential margin (at a given market price) on the product, and the less other costs could be included CBAM: in the case the CBAM applies for imported products, the additional costs of CO_2 pricing is included and conditions for competition are adjusted. For exported goods, domestic producers are not yet compensated for additional costs due to CO_2 prices.

Table 4: Overview on product features

Aspect	Description	Level	Indicator
Cost shares	Cost share of CO_2, of energy	EU, Germany	€/t
Price dependency of demand	How have demand and prices evolved over time? Spot market prices and contract or forward prices? Import values and quantities as proxy for prices and domestic demand	Global, EU, Germany	Development and correlation of prices (€) and sales (t)
Transport costs	Transport costs per unit and distance within and outside the EU	EU or Germany	€/t km
CBAM	Part of CBAM? In case CBAM fully compensates for CO_2 costs, domestic suppliers face no disadvantage from CO_2 on the EU market.	EU	Yes/no

3 Results

In order to make it easier to understand the use of data and the conclusions, a table at the beginning of each indicator category provides a brief overview on the applied indicators, reference product, year, source, scope and conclusion with respect to its impact on the passing through of cost increases (- rather no-passing-through; + rather passing-through).

3.1 Hot rolled coil

Table 5 provides a brief overview on the classifications used in the subsequent section. The section provides data and qualitative information on the indicators outlined in section 2.

Table 5: Overview on used product classes - HRC

	Description	Products
C2410	Manufacture of basic iron and steel and of ferroalloys	Manufacture of iron, steel and products of first transformation
24103110	Flat-rolled products of iron or non-alloy steel, of a width >= 600 mm, simply hot-rolled, not clad, plated or coated, in coils	Hot rolled coil
24103130	Flat-rolled products of iron or non-alloy steel, of a width >= 600 mm, not in coils, simply hot-rolled, not clad, plated or coated, with patterns in relief directly due to the rolling process and products of a thickness < 4,75 mm, without patterns in relief (excluding rolled on four faces or in a cl	
24103150	Flat-rolled products, of iron or non-alloy steel, of a width >= 600 mm (excluding `wide flats¿), not in coils, simply hot-rolled, not clad, plated or coated, without patterns in relief; flat-rolled products of iron or steel, of a width >= 600 mm, hot-rolled and further worked, but not clad, plated o	

Source: Eurostat 2020b; Eurostat 2021

Competition

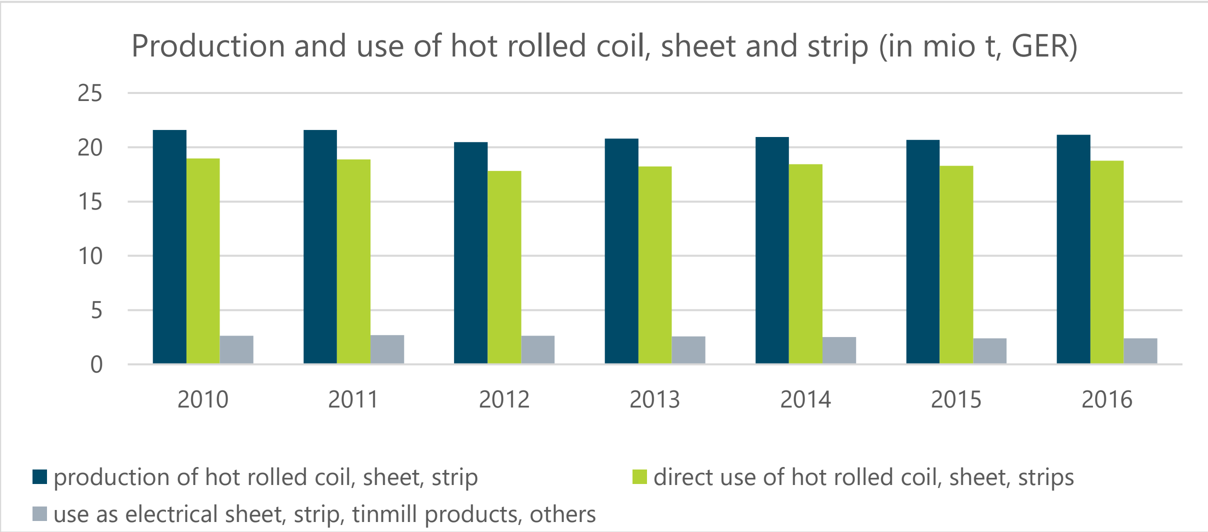
Table 6: Overview on indicators of competition in HRC

Aspect	IN	Level	Indicator	Findings	Passing-through
Variety of customers	1	Germany	Share of B2C, B2B, I	B2C: none C2C of HRC, sheet and strip (2016, WSA)): 80% (50%) direct use of HRC, sheet and strip in Germany (EU) 20% (50%) use for other products (EU) C2C of steel (2018, WV Stahl, Germany): 18.4% of steel direct to automotive 30.6% of steel to SSC/dealer C2C of strip mill products (2020, Eurofer, EU): 54.3% direct use of strip mill products, of which 40.7% for automotive I: n.a.	Low variety: -
Exposure to global market	2	Germany	export as % of domestic production	Export, average 2008-2026: 4% Germany (hot rolled wide strip, hot rolled narrow strip, wide flats, lengths cuts from Eurofer to HRC sheet and strip from WSA) 5% EU (Prodcom 24103110/30/50 to HRC, sheet and strip from WSA)	existing exposure of about 4%: (-)
Homogeneity	3	Global, EU, Germany	Yes/no	Product differences by: production costs: HRC from BOF less expensive than from EAF (JRC 2020) Product quality: n.a. Services: n.a.	Limited product diversification: n.a.
Intensity of competition	4	Germany	Market price per unit to average total costs (AC)	Product prices (HRC, sheet, strip; Steel on the net, 05/2019-02/2020, €/t), also see UBA (2024): global average: 523 European average: 429 Asian average: 482 North America average: 612 Export values (Eurostat Prodcom 24103110/30/50, 2019): €575/t of Germany to global market €529/t of EU to global market Unit costs production of HRC, see UBA (2024) BOF: €458/t in Germany; €450-475/t in 2019, EU average (JRC 2020) EAF: €486/t in Germany; ca. €490/t in 2019, EU average (JRC 2020)	Rather P< AC: -

Source: WSA 2018; Eurofer 2022; WV Stahl, VDeH 2016; Steelonthenet 2020c; JRC 2020; Eurostat 2020b
Note: n.a.: no assessment possible; IN: indicator number - low potential for passing through, + high potential for passing through

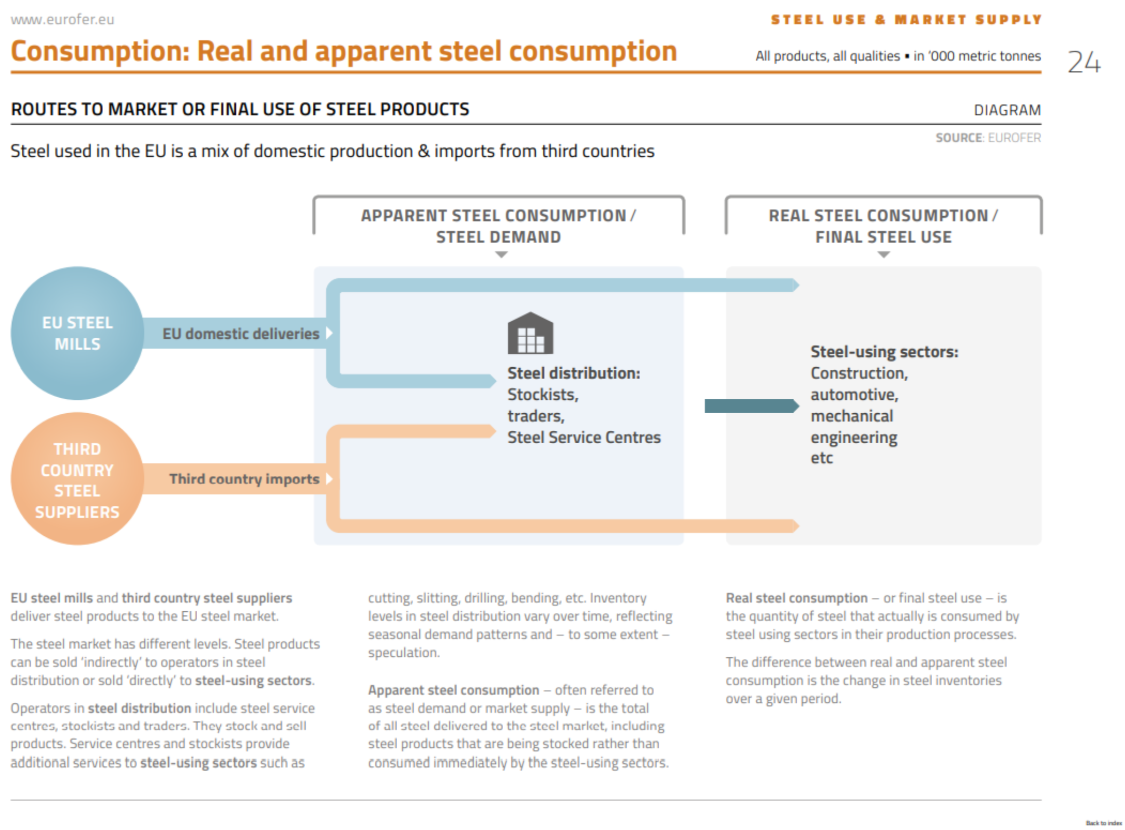
Demand for hot rolled coil comes mainly from the construction and automobile sector. In the automobile sector, it is used for the vehicle body but also for wheels, dampers, seats. Due to security aspects, applications of recycled steel from scrap is less likely. The largest share of hot rolled coil, sheet and strip are used directly. This has hardly changed over time (see Figure 2).

Figure 2: Production and use of hot rolled coil, Germany



Source: WSA 2018

Figure 3: Routes to the market



Source: Eurofer 2022

Regarding market routes, HRC takes several different routes to the market as depicted in Figure 3. It shows two main sources of steel –domestic and foreign – and potential distributors such as stockists, traders, and steel service centres that supply different industries. Data on the main routes are not available. Customers of steel products are production companies such as automobile sector, steel pipe industry, construction sector, and service providers such as steel traders. Therefore, for hot rolled coil, a B2C market does not exist, as HRC is not a final product but needs further processing.

Table 7: Deliveries of steel products by industrial customers, Germany

	2013	2014	2015	2016	2017	2018
Steel pipe industry	13.3	13.2	12.1	12.6	13.2	12.7
Cold strip	6.7	6.8	6.5	5.0	5.9	5.9
Automotive and other vehicle construction	14.3	14.4	15.1	15.8	17.9	18.4
Distributor/ SSCs	30.4	28.8	28.9	28.7	32.1	30.6
Mechanical engineering (excl. electr. machinery)	2.2	1.7	1.8	1.7	2.3	1.7
Mechanical engineering - electr. machines	1.4	1.2	1.1	1.1	1.5	1.3
Forged, pressed, drawn & stamped parts	5.8	5.2	5.4	5.3	4.2	5.1
Wire and rod drawing factories	4.7	4.8	4.8	4.7	1.8	1.2
Metal products	3.2	3.2	3.2	3.5	2.6	2.9
Steel construction and building industry	12.3	11.4	12.5	13.6	12.5	11.6
Other customers	5.7	9.3	8.6	8.1	6.0	8.6

*as of 2017 changed survey
Source: WV Stahl; VDEh 2016

In the EU, about 52% of hot rolled coil, sheet and strip is delivered directly to end-use sectors, while the remaining share is further processed and traded through steel service centres and merchants (Steel Statistical Yearbooks der WSA). The automotive sector is with about 41% of hot strip mill product purchases (European Steel in Figures 2021, Eurofer) the largest end-user, followed by buildings (construction) and tubes[1]. Neither for the EU nor for Germany it is clear whether the further processed products made of hot rolled coil are typically produced at the same company (I) or another location (B2B).

Based on the Steel Statistical Yearbooks of the WSA, we estimated[2] that in Germany on average 80% of the hot rolled coil is either delivered directly (2008-2016) and the remaining production (20%) is further processed (WSA 2018). The distribution of all direct deliveries of steel products can

[1] Tubes are considered aggregated in the statistics (UBA 2024), thus no further distinction is possible. Cullen et al. (2012) state that tubes are mainly used in the construction sector and for industrial equipment on the global level. However, this may very on EU or national level.

[2] As described in the statistics and UBA (2024), steel products are traded either in their semi-finished/hot rolled form or further processed. Statistics, such as WSA (2018), can be used to calculate the respective share since production quantities for both types are published (semi-finished/hot rolled and further processed products). However, hot rolled flat products include besides hot rolled coil also hot rolled plate. Thus, we used Cullen et al. (2012) to allocate the further processed forms. In general, the allocation of the further processing is unequivocal with one exception: welded tubes. For this, we used the share from literature (Cullen et al. 2012). Since the production quantity of welded tubes is comparatively low, the possible deviation is small compared to the total production of hot rolled coil.

be seen in Table 7. A specific distribution of hot rolled coil is not available for Germany, but EU data can be used as proxy.

Exports of German and EU products (hot rolled wide and narrow strip, lengths cut and wide flats) compared to production (hot rolled coil, sheet and strip) range around 4% or 5% of total production in Germany or the EU, respectively. While this share is relatively constant at the EU, it is slightly decreasing for Germany. Albeit this share is low, it shows to what extent, e.g. German producers face a global market, and thus, likely competition.

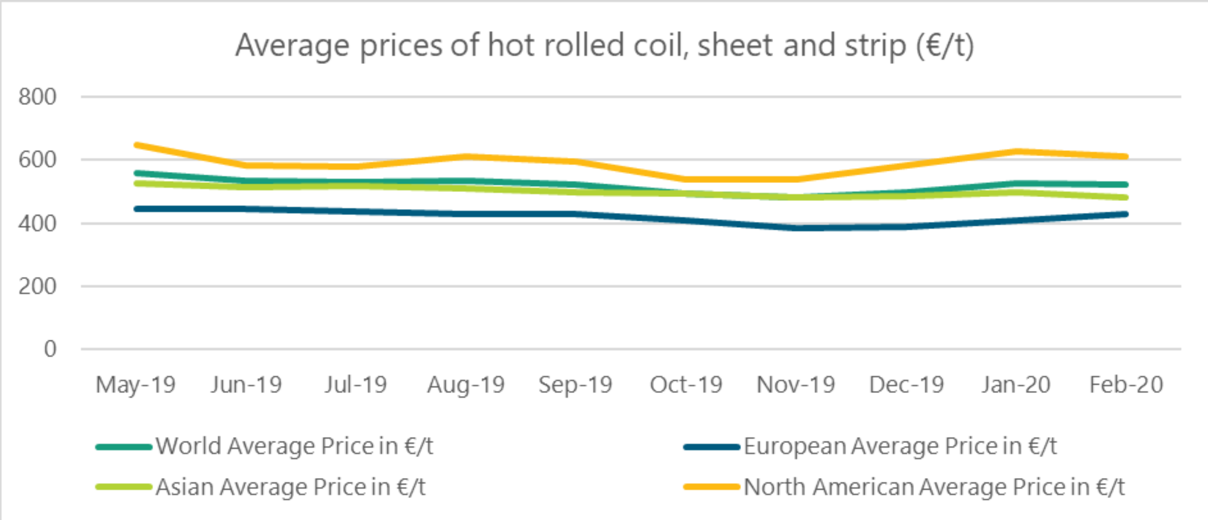
Regarding the product homogeneity, hot rolled coils could differ in their production process and material composition, which leads to slight differences in quality. According to a study by Ecorys (2008), in particular, the automotive industry has high quality requirements, e.g. high strength and light weight. Thus, the largest share is produced of BF/BOF steel, while EAF steel is less used because it fulfils not yet the quality requirements for components in automobiles (Ecorys 2008; Cullen et al. 2012). So far, further data considering other differences in material composition are not available for hot rolled coil (Ecorys 2008; JRC 2020). Thus, other distinct product features cannot be derived from the results of section 2, literature (JRC 2020; Ecorys 2008) or statistics (WSA 2018).

The existence of different regional prices point to the existence of regional markets, of which Europe displays the lowest prices. This signals a competition in the market, as well as barriers between markets; otherwise prices should be rather similar. The assessment of production costs is based on input costs for labour, raw material, energy and other factors (e.g. intermediate products, capital expenditures). It ranges around EUR 458 /t for BF/BOF steel (in 2019)[3]. The costs are below those in the US, and Ukraine, but above those of other large producers such as Brasilia, Turkey, China (JRC 2020). The costs of EAF based hot rolled coil are around EUR 486 /t in the EU (27) (JRC 2020). The prices in Figure 4 are averages of hot rolled coil, sheet and strip prices and thus not fully comparable to the costs of HRC[4]. Temporarily, under a tough competition, HRC could be sold at market prices below the average costs as long as variable costs of production are covered. In contrast, the export value per t of hot rolled coil (24103110/30/50, Prodcom) is EUR 529 /t for the EU in 2019.

[3] Section 2

[4] As prices and costs are based on different aggregated flat steel groups, a direct comparison (one by one) is not feasible. This is a general challenge we face with the data.

Figure 4: Regional prices of hot rolled coil, sheet and strip



Source: see Figure 13 - Figure 15, MEPS 2020

Overall, we find that hot rolled coil are products of a B2B market, in which a large share is directly forwarded to end-use producers. However, it is unclear whether or to which extent this share of HRC producers is integrated in large corporation encompassing end-use producing units and or to which extent HRC producer deliver their products to companies with which they have a long-term contract. The remaining share is traded through merchants/traders. Albeit only a small share of around 5% (4%) of the EU (or German) production is exported (excl. intra-EU trade), this share signals an exposure of 5% of domestic production to global competition. As statistical information on product differentiation such as differences in quality are not available in this granularity, we cannot assume that price differentiation is feasible or not. However, we find that the market price in the EU (2019-2020) is lowest while the production costs are at the upper global range (2019). Further, the margin between the EU average price and the calculated production costs might temporarily be negative, but when compared to the EU export value (2019), it is positive. Similarly, for Germany, the production costs (see UBA (2024)) are above the EU average price (2019-2020), but below the export value (2019). Given that three out of four indicators (Table 6) imply a certain degree of competition, but not full competition in the market for HR in the EU and Germany, we assume no or limited potential of cost passing-through.

Market structure - supplier side

Table 8: Overview on indicators of market structures of HRC

Aspect	IN	Level	Indicator	Findings	Passing-through
Market size	5	Global, EU, national, local	Market and prices in €/t	Several large regional and global markets (MEPS 2020, see indicator IN 4 in Section 2.1, and Figure 4): global market 3 large regional markets	Large markets -> price takers: -

Aspect	IN	Level	Indicator	Findings	Passing-through
Market participants	6	Global, EU	Numbers of producers	Producers: crude steel producer with > 3 Mt/year, 2020, WSA: EU: 10 global: 107 HRC producer in 2019, JRC 2020 report, EU: 19	n.a.
Market share	7	Global, national	% of top 5 (global) % ranks (Germany) % export share to global exports for EU, Germany	Market shares of crude steel producers, 2020, WSA: share of top 5 global suppliers is 17%, no German supplier share among top 10 EU suppliers: German suppliers hold a share of 1.08%, and are of rank 2nd, 7th, and 10th Export share of Germany or EU producers (Prodcom 24103110/30/50) to global market (HRC, sheet and strip, WSA) in 2019: exports share, Germany: 5% export share, EU: 5%	Exposure to global market: -
Market entry, market exit	8	Global or EU	Number per year (or each 2, 5 or 10 years)	Number of companies manufacturing of basic iron and steel and ferro-alloys (C2410), SBS 2011-2019 for Germany and EU: changes between consecutive years range between -17 and +15% in Germany, and -2 to + 8% in the EU "Consolidation process in European steel industry results in few companies with large share of steel production. This indicates the presence of market entry barriers, probably caused by economies of scale and high capital intensity; ... large multinational companies dominate the steel industry" (Ecorys 2008)	High dynamics: -
Intensity of rivalry	9	Global Germany	Yes/no, examples Sales (€)or production (t) over time	no new industry Turnover between 2011-2018 of companies manufacturing basic iron and steel and ferro-alloys (C2410), SBS, Germany and EU: variations between -10% to + 18% (Germany) and -9% to + 17% (EU)	High volatility: -

Note: n.a.: no assessment possible; IN: indicator number; - low potential for passing through, + high potential for passing through

As outlined above, there are regional markets with differing prices for hot rolled coil, sheet and strip. The number of hot rolled coil producers is not available; instead, we use the number of the crude steel producers as a proxy for hot rolled coil manufacturers. Chinese companies, as well as

Japanese and ArcelorMittal in Luxembourg are the top 5 producers of 107 producers (>3Mt/year) worldwide, covering 16% of global production. In the EU, 10 producers (>3Mt/year) are active, of which German and Ukrainian producers follow the Luxemburg production site (ArcelorMittal) in volume of output in 2020. This situation might have changed due to the Russian-Ukrainian war. Currently, an analogous overview by WSA on production in 2021 and 2022 are not available.

Table 9: Overview of top crude steel producers (2020)

	in Mt (2020)	Share
Total steel production in t (global)	1,880.41	
whereof the top 5 globally:		
Production Baowu in t (China)	115.29	6.1%
Production Arcelor Mittal in t (Luxembourg)	78.46	4.2%
Production HBIS in t (China)	43.76	2.3%
Production Shagang in t (China)	41.59	2.2%
Production Nippon in t (Japan)	41.58	2.2%
whereof the 10 largest in Europe:		
Production ArcelorMittal in t (Luxembourg)	78.46	4.2%
Production Thyssenkrupp in t (Germany)	10.73	0.6%
Production Metinvest in t (Ukraine)	10.16	0.5%
Production SSAB in t (Sweden)	7.54	0.4%
Production CELSA in t (Spain)	6.90	0.4%
Production voestalpine in t (Austria)	6.69	0.4%
Production Salzgitter in t (Germany)	6.03	0.3%
Production RIVA in t (Luxembourg)	5.11	0.3%
Production ISD in t (Ukraine)	4.53	0.2%
Production HKM in t (Germany)	3.50	0.2%

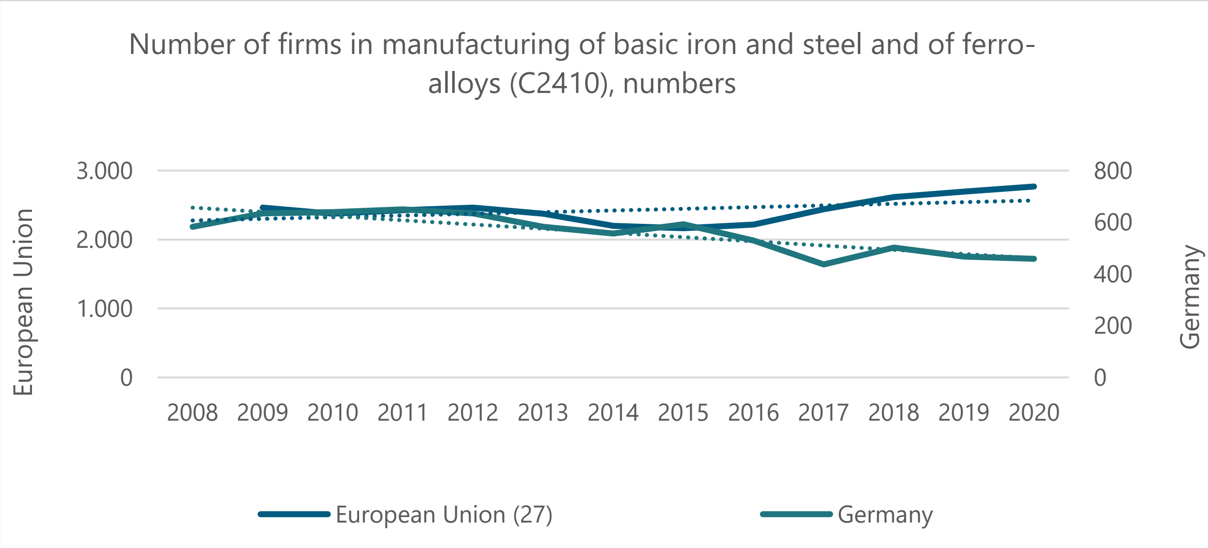
Source: WSA (2020a)

Regarding the significance of exports or imports, the share of EU exports (and imports) of hot rolled coil compared to the global exports of this product ranges around 4-5%, (Prodcom, WSA).

The number of market entries and exits is only available at the aggregated level of manufacture of basic iron and steel and of ferro-alloys, and is the difference between the number of companies in the current and previous year. There is an increasing trend in the EU, while in Germany, the numbers are decreasing (see Figure 5). The changes in consecutive years range between -17% and +15% in Germany, and in the EU, between-7% and + 10% from 2010 to 2020, both pointing to an agile market with market exits and entries. However, the slightly negative trend in the number of firms for Germany might indicate a consolidation of the market, similar to that of the EU till 2016. The trend in the EU has reversed since 2016. A study of Ecorys (2008) describes the former development at the EU level (p. 56): "As a result of consolidation in the European steel industry, relatively few companies account for a large share of the steel production. This indicates the presence of entry barriers to new companies - most likely caused by high capital requirements and economies of scale. Apart from foundries and the casting industry, large, multinational companies dominate the steel industry, albeit to a lesser extent than other sectors." Albeit a potential consolidation, the high fluctuation in the number of firms signals a clear competition in the market.

"However, the world steel industry is still less international and more fragmented than other sectors. The top 10 largest producers turned out 30% of the production (2006) – whereas the top 10 household appliances producers turned out 80%, and the top 10 automobile producers turned out 95%. In other words, there is room for further consolidation and internationalisation of the sector. Thus, the current consolidation phase is expected to continue - a factor which is strategically important from a competitive perspective, e.g., to increase negotiating its power with its main suppliers and customers." (Ecorys (2008)).

Figure 5: Number of basic iron and steel and of ferro-alloys manufacturers in Germany and EU (28) over time[5]

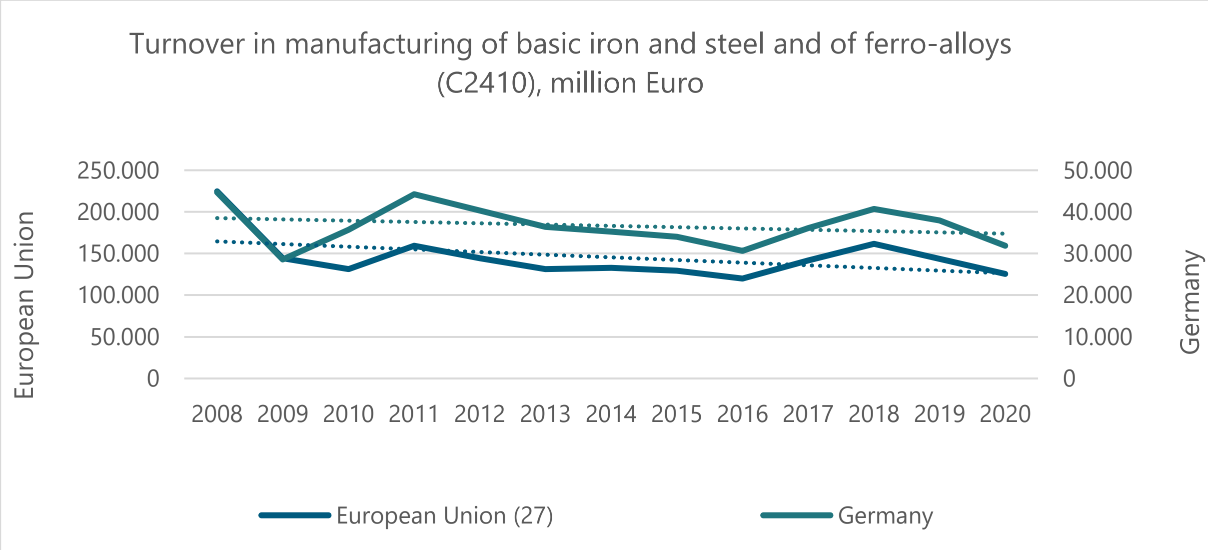


Source: Eurostat SBS, Annual detailed enterprise statistics for industry (NACE Rev. 2)

Regarding intensity of rivalry, we look at the turnover of companies producing basic iron and steel ferro-alloys (C2410) and find variations between consecutive years of -16% to + 25% (Germany) and -13% to + 21% (EU) between 2010 and 2020. This points to a very dynamic market and rivalry, supporting the assumption of a strong market competition (see Figure 6). It is to note that the turnover is also driven by the general economic development in the EU and Germany, respectively.

[5] Note: company is understood as a legal organisational unit producing goods or services with a certain degree of autonomy in decision-making.

Figure 6: Overview on turnover of the steel sector over time in Germany and the EU



Source: own illustration based on Eurostat SBS, Annual detailed enterprise statistics for industry (NACE Rev. 2)

Based on these findings, the crude steel market is characterised by large, globally acting manufacturers many of which have integrated hot rolled coil production (Ecorys et al. 2008). Besides vertical integration, trade of hot rolled coil takes place through merchants and steel service centres based on current market conditions or purchase agreements or contracts[6]. The slightly decreasing trend in the numbers of companies manufacturing basic iron and steel and of ferro-alloys) in Germany points to a strong competition in the market. Given that five out of six indicators on the market structure point to a competitive market (Table 8), we conclude that the market of HRC producers is competitive and passing through of prices is challenging.

[6] Often limited to a given period of time; could also be indexed to an index.

Environment of the company

Table 10: Overview on indicators of the business environment of HR

Aspect	IN	Level	Indicator	Findings	Passing-through
Integration	10	German companies	% of production/sales per type (I, L)	no data; for qualitative assessment see indicator 1 "Many foundries are a part of an OEM. E.g. Daimler, BMW and VW have their own foundries. ..... data covering the EU15 from Eurometal ...... Of a market supply of 150 million, 50 million are direct mill sales (approx. 33%), 40 million are sold to SSC companies (approx. 25%) and 60 million are sold to steel stockholding companies (approx. 40%). In this regard, it should be noted that direct sales figures might be underestimated." (Ecorys 2008)	n.a.
Substitutes	11	Global	Yes/no actual or hypothetical substitution	Yes: The substitution of steel in vehicles is currently being conducted mainly for light-weighting. The main aim is to reduce fuel consumption for the same vehicle size. Various materials are available for this purpose: aluminium, magnesium-alloys, fibre-reinforced polymers and advanced high-strength steels. For the first three, the environmental impact is estimated to be higher than for steel, especially when recycling is considered. Higher production costs apply to all of them. A complete substitution of steel is not possible. For the substitution of hot rolled coil aluminium is most relevant, the other materials are typically used for other components (Geyer, 2016, European Aluminium 2023)	-

Aspect	IN	Level	Indicator	Findings	Passing-through
Sales market	12	Global	Number of automotive customers Alternatives: yes/no; brief description	Number of automotive producer (www.oica.net, 2017): globally about 22 with a market share above 1%, few large players with market shares >10% such as Toyota and Volkswagen (VW), many smaller producers with shares below 1% EU: few large producer such as VW, Fiat, Renault, Daimler, BMW. Germany: large dominating automotive producer such as VW, Daimler, BMW. Alternatives: other, large sector using strip mill products are the building and steel pipeline sector, prices are not higher (see indicator 1)	- for Germany and EU
Product innovation	13	German companies	Yes/no	With increasing quality of scrap steel, EAF steel could be used for HRC (Dworak et al. 2022). Alternatives with new material are not yet available	n.a.
Process innovation	14	German companies	Yes/no	For the production of high quality steel also steel made from the direct reduction of iron can be used**.	new product feature: +/-

** see section 2.3.1

Note: n.a.: no assessment possible; IN: indicator number; - low potential for passing through, + high potential for passing through

Along the value chain from steel producers to equipment manufacturers, several intermediaries' further process the intermediate product until it is delivered to the automotive industry. The intermediaries between mills (upstream part) and the equipment manufacturers (downstream part) of the intermediated product include service centres, stockists, contract manufacturers and component suppliers. They add value to the product by stockholding or by processing standardised raw materials to the specific sizes, shapes and tolerances required by the customers. The value added provided by intermediaries, thus, includes services in different positions along the supply chain. In the steel-automotive sector, many foundries are integrated in an OEM (original equipment manufacturer), for example, Daimler, BMW and VW have their own foundries. No data has been found regarding the quantity and structure of distribution channels of EU (27). But data covering the EU15 (Eurometal) gives an indication. 50 million are direct mill sales (approx. 33%), 40 million are sold to Steel Service Companies (SSC) (approx. 25%) and 60 million are sold to steel stockholding companies (approx. 40%), of a total of 150 million euros. However, it is important to note that direct sales figures might be underestimated, as, for example, data from Eurofer report higher direct sale numbers with 80 million tons being directly sold to end-users, and sales to SSCs and merchants/stockholding companies are equally reported to be 100 million tons.

Steel producers face a continuously changing environment when looking at the automobile sector. To reduce the weight of automobiles and increase energy efficiency (reduce fuel consumption), the industry is replacing steel by different materials, which have a lower weight than steel, such as aluminium, magnesium alloys, fibre-reinforced polymers and advanced high-strength steels. These substitutes are more costly and less environmentally friendly to produce, especially if compared with recycled steel. However, a complete substitution of steel is not feasible and for hot rolled coil, the typical substitute is aluminium, while the other steel-substitutes are used instead of the other steel-components. In contrast, incremental changes in the production process leads to products with new features potentially substituting the conventional processed products as in the case of steel from direct reduced iron. It is possible to use it for all components in vehicle body, doors, wheels, dampers, components within the gearbox etc. For example, two German automotive producers as well as one supplier established contracts with a Swedish start-up in 2021 to buy 'green' steel. This start-up focusses on the use of direct reduced iron in the EAF and furthermore ensures the recycling of new scrap from the steel purchasers in the EAF. In contrast, the use of recycled steel from old scrap is less likely due to quality requirements (VDI 10/2021, Automobil-Produktion 5/2021, Automobil-Industrie 11/2021). However, EAF steel for hot rolled coil is not yet commonly used in the automotive industry, as this type of steel from old scrap does not match with the high quality requirements. Recycled steel might be of lower quality due to the contamination with other trace elements (Cullen et al. 2012, Pauliuk et al. 2017, Dworak et al. 2022). With respect to passing through of higher costs, we find that HRC could be substituted in the long-term by products composed of other materials or with a sustainability label (direct reduced steel). On the one hand, this potential substitution reduces the potential of passing through higher costs in the downstream value chain. On the other hand, new or changed product features allow differences in prices.

When looking at the main customer of the steel industry - the automotive sector -, we see a large number of automobile manufacturers that are dominated by a few large producers - Toyota and Volkswagen at the global level (in 2017). However, the Herfindahlindex of about 0.05 (global market) implies a competitive B2B market for intermediate steel component producers, with a low concentration of market power at the global level. Within the EU, a large share of automotive manufacturing is located in Germany, France and Spain, with dominating producers such as Volkswagen, Fiat, Renault, Daimler and BMW at the EU level, and the three German companies at the national level). Alternative sales market for strip mill products theoretically comprise the building sector and the steel pipeline industry (see indicator 1), but prices are not expected to be higher.

Regarding the business environment, we find strong market participants at the customer side and potentially emerging substitutes, both reducing the possibility of passing through rising costs of the conventionally produced product (see Table 10).

Product level

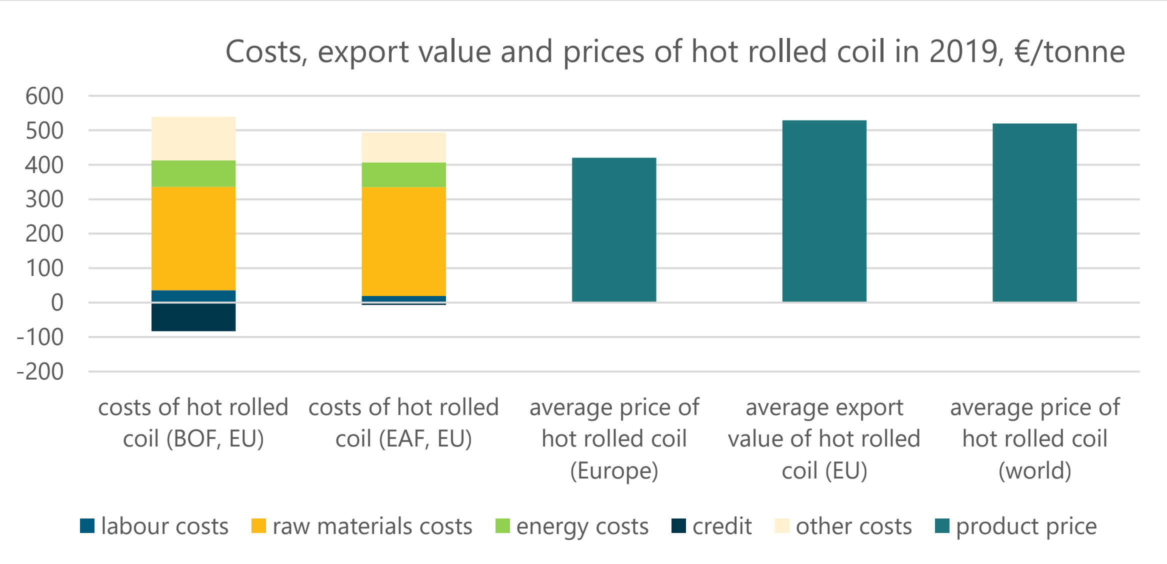
Table 11: Overview on product features of HRC

Aspect	IN	Level	Indicator	Findings	Passing-through
Cost shares	15	EU, Germany	€/t	Unit costs EU see UBA (2024) and indicator 4): unit costs €458/t BOF, €486/t EAF in 2019 (JRC 2020) energy costs between 15% and 18% of total cost; global average price of €520/t, see UBA (2024); emissions see UBA (2024)	Significant cost share: -
Price dependency of demand	16	Global, EU, Germany	Time series of prices (€) and sales (t)	Prodcom C24103110/30/50, 2008-2016: import volumes and values of Germany and EU show now price sensitivity of demand Export values of Germany and EU reveal a declining trend Export volumes of EU reveal a declining trend, of Germany no declining trend	Declining values: -
Transport costs	17	EU or Germany	€/t km	Transport costs amount to 5 to 15% of the selling price (Ecorys 2008). About 30% of all finished steel products are transported across countries (Ecorys 2008)	Significant share: -
CBAM	18	EU	Yes/no	Compensation for reduction of cost-free CO_2 certificate allocations, for imports; no compensation for exports;	exports: -

Note: n.a.: no assessment possible; IN: indicator number

Steel is a very "trade- or transport-intensive" product, i.e. about 30% of steel products are traded worldwide. Depending on the transport mode, the location and distance, transport costs amount to about 5-15% of the selling prices (Ecorys 2008). Transport modes within Europe encompass rail, road and water. The mix of these three transport modes varies between country and country, but a high share is transported via railways (due to its heavy and bulky products). Other cost components are labour costs, raw material costs and energy costs (compare UBA (2024)). Comparing the total of all costs with the global and European average market price (03/2019-02/2020) and EU export values for HRC (see indicator 4 in Table 8 and Figure 3), the BOF and EAF based hot rolled coil display a negative margin under the European market price, while both reveal a small positive margins if they could be sold at the average world market price (see Figure 7). Any additional costs come at the expense of the margin if they cannot be passed through in a competitive environment.

Figure 7: Cost shares of hot rolled coil manufacturing and prices[7]

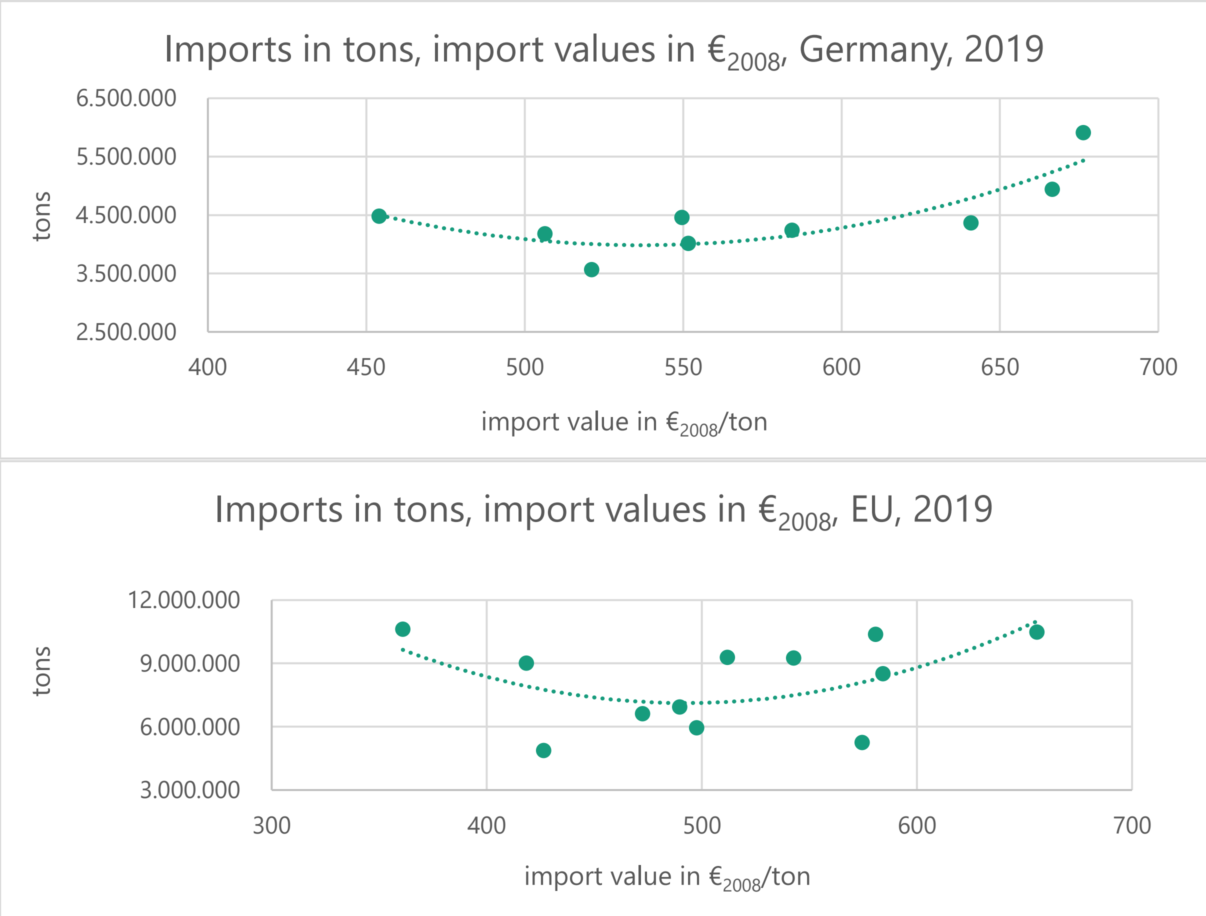


Source: own depiction, data listed in UBA (2024), based on Medarac et al. 2020.
Note: Credits are generated from savings when raw materials are recycled inside the facility instead of purchased from external sources, or when energy is self-generated. By definition, they decrease total costs, but in some cases, for instance when the recycled material can be sold to others, they may also increase total costs. Transport costs of steel comes on top of the market price.

To answer the question how sensitive customers (automotive industry) react to price increases of hot rolled coil, we analyse the price and related demand of hot rolled coil in Germany and the EU. As we do not have specific information on the individual contracts and prices, we use the import volume and prices as a proxy for the price sensitivity of domestic demand. When calculating the changes in import values and volumes per year, we find years in which a decrease in values goes hand in hand with a decrease in volumes, and years in which an increase in prices goes hand in hand with an increase in volumes, both in Germany and the EU. Thus, it looks like price sensitivity of demand is superimposed by economic and market developments. The correlation of import values and quantity is depicted in Figure 8 in form of points and a trend line: at a lower price level an increase in import values is associated with slightly decreasing import volumes while at a high value level the import volumes even increase. Changes in the quality of hot rolled coil as well as a general increase of the production price or consumer price index influence the illustrated relationship. Therefore, it is hard to derive any indication about the potential price sensitivity of demand for hot rolled coils in Germany and the EU Overall, the demand, depicted as apparent steel use as well as the import quantity to Germany (between 10-14% of demand), is depicted in Figure 9. We find a high correlation between steel use and imports for Germany. Apart from a decline in 2009, it reveals a rather stagnating use of steel in Germany in recent time, underpinning the assumption, that the economic situation is determining demand, and finally, affects prices.

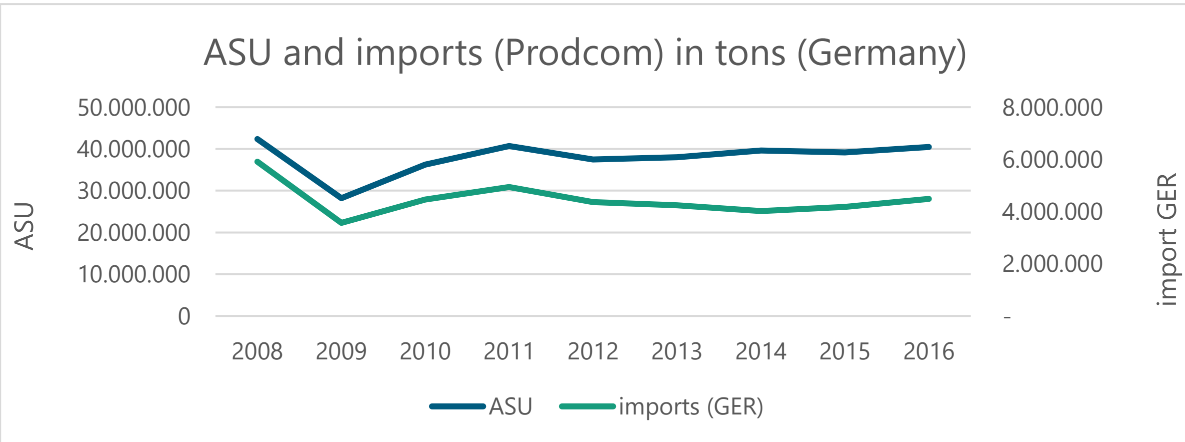
[7] Note: Credits are generated from savings when raw materials are recycled inside the facility instead of purchased from external sources, or when energy is self-generated. By definition, they decrease total costs, but in some cases, for instance, when the recycled material can be sold to others, they may also increase total costs. Transport costs of steel come on top of the market price.

Figure 8: Import volumes and values (price base 2008) of hot rolled coil, Germany[8] and EU



Source: own depiction, based on Eurostat (Prodcom, C24103110/30/50)

Figure 9: Apparent Steel Use (ASU) and imports in Germany, [t]



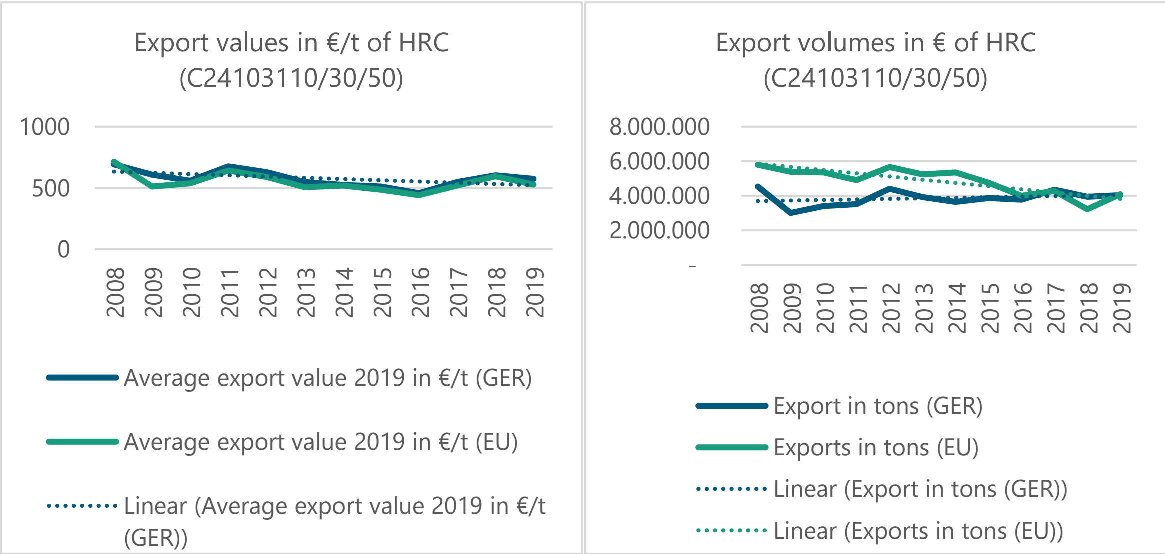
Source: own depiction, based on Eurostat (Prodcom, C24103110/30/50)

In addition, the illustration of the export values per unit of product and the total export volume over time emphasis the declining trend in export values for both, Germany and the EU, while the export volume declines for the EU, but increases for Germany. This indicates a certain

[8] Note: at prices of 2008; price and quantity display a u-shaped relationship

attractiveness of the export market for the German producers albeit declining export values per unit. Based on this finding and the significant cost shares for energy and transport, we conclude that the scope for passing through of higher costs is small in the international market, and higher costs are expected to decrease (profit) margins per unit of product, if there is any.

Figure 10: Export volumes in t and values in Euro (nominal)/t of hot rolled coil, Germany and EU



Source: own depiction, based on Eurostat Prodcom (C24103110/30/50)

3.2 Polyethylene (PE) and polypropylene (PP)

In this section, we look at the so-called "ETS products" of the chemical industry. As an example, we choose the polymers of ethylene and propylene. These polyethylene (PE) and polypropylene (PP) are produced in the sector "manufacturing of plastics in primary forms" (NACE 20.16) and are further processed in the "Manufacture of plastic products" (NACE 22.2) - see Table 12. The plastics processing industry usually obtains the polymers in form of plastic pellets. It adds necessary additives (pigments, UV stabilisers, etc.) and transforms them into plastic products using plastics processing methods such as extrusion (continuous) or injection moulding (discontinuous). The energy input for plastics processing (3 MJ/kg) is significantly lower than that for the production of ethylene/propylene in the steam cracker in the upstream chain (16.5 MJ/kg). The polymerisation of ethylene and propylene ("primary plastics production") is exothermic and it requires with 2.5 to 3.2 MJ/kg also little additional process energy (mainly electricity). The value chain from refineries to final products is outlined in Figure 11.

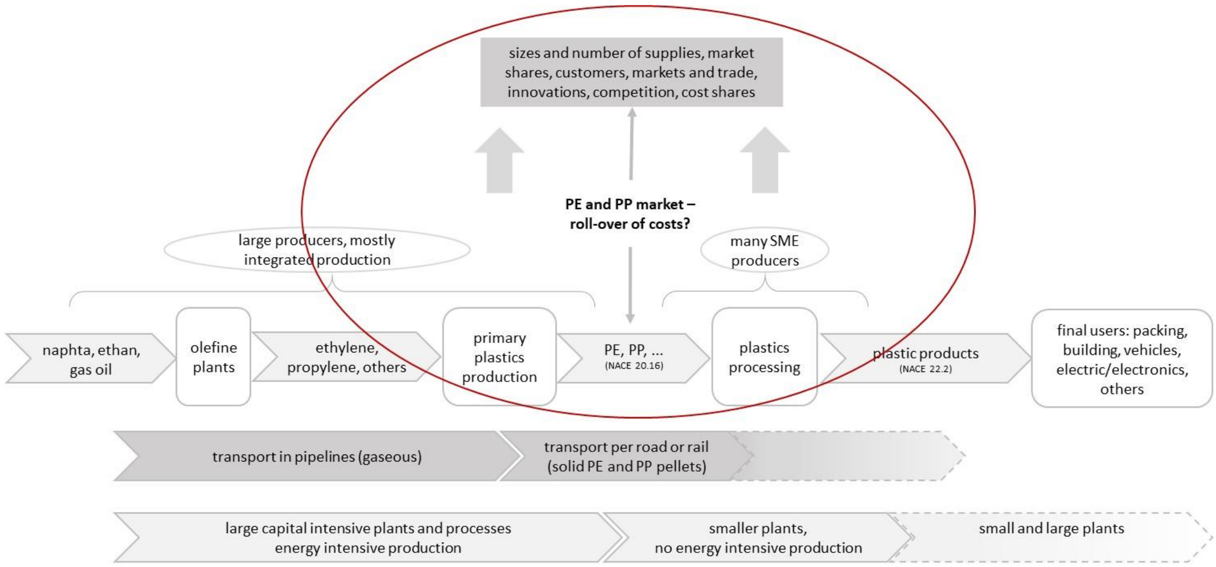
Table 12: Overview on used product classes - PE and PP

NACE class	Title	Description
22	Manufacture of rubber and plastics products	
22.1	Manufacture of rubber products	
22.2	Manufacture of plastics products	

NACE class	Title	Description
	22.11	Manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres
	22.19	Manufacture of other rubber products
	22.22	Manufacture of plastic packing goods
	22.21	Manufacture of plastic plates, sheets, tubes and profiles
	22.23	Manufacture of builders ware of plastic
	22.29	Manufacture of other plastic products
20.16	Manufacture of plastics in primary forms	This class includes: manufacture of plastics in primary forms: Polymers, including those of ethylene, propylene, styrene, vinyl chloride, vinyl acetate and acrylics polyamides phenolic and epoxide resins and polyurethanes alkyd and polyester resins and polyethers silicones ion-exchangers based on polymers. This class also includes: manufacture of cellulose and its chemical derivatives

Based on the value chain and structure of this industry, the key focus of this analysis is on the PE and PP market, but also includes the plastics processors´ downstream customers and markets (NACE 22.2).

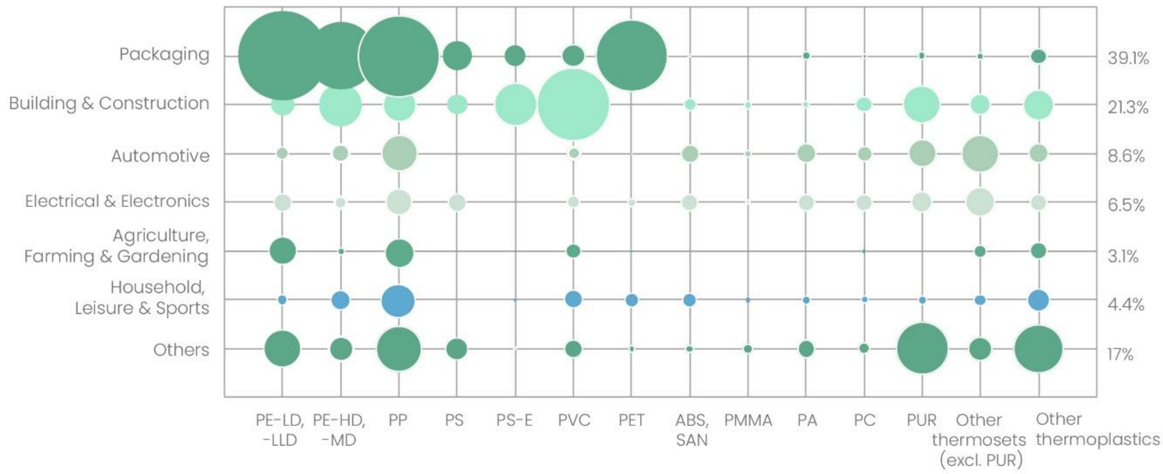
Figure 11: Focus of the analysis in the plastics industry



Source: own calculation

Illustrations in UBA (2024) underline the significance of PE and PP as key inputs in plastic products used for the production of vehicles, buildings, packaging and electronics. Figure 12 illustrates the significance of PE and PP in primary plastics productions, as they account for about almost 50% of the total primary plastics demand in Europe.

Figure 12: European plastics converters: demand by application and type 2021



Source: PlasticsEurope (2022)

In the following, we analyse the competition and market of PE/PP pellets (NACE 20.16) but also include the downstream market and customers of the processed plastic products (NACE 22.2 - Manufacture of plastics products - or NACE 22 - Manufacture of rubber and plastics products) as far as data is available.

Competition

Table 13: Overview on indicators of competition in PE and PP

Aspect	IN	Level	Indicator	Findings	Passing-through
Variety of customers	1	Germany	Share of B2C, B2B, I	NACE 20.16, PE and PP market: large suppliers of PE and PP (NACE 20.16) many small plastic processors at the demand side (NACE 22.2) NACE 22.2 supplies three main sectors (2015, Consultic 2016): Packaging sector (PP: 44% PE: 66%), Building and construction sector (PP: 9%, PE: 14%), Automotive industry (PP: 16%, PE: 4%). NACE 22: B2C 6% (e.g. Gardena), B2B 55% (e.g. Rehau)	NACE 20.16: high + NACE 22.2: low -
Exposure to global market	2	Germany	export as % of domestic production	NACE 22 (2018, Input-Output table Destatis): GER exports 40% of production GER in EU: 27,8% of production GER in rest of world: 12,3% of production HS 39 (plastics and articles thereof, Eurostat) imports are increasing	Relative high export share: -

Aspect	IN	Level	Indicator	Findings	Passing-through
Homogeneity	3	Global, EU, Germany	Yes/no	PE and PP not completely homogeneous, as differences in: length of their carbon molecules, molar mass distribution, branching type, and other features, e.g. quality, delivery in time, proximity to customer, etc. prices of export, imports, EU, GER and markets vary (see UBA (2024)) signaling price differentiation and potentially different product features	Use in different applications: partly yes: (+) Different prices: +
Intensity of competition	4	Germany	Market price per unit to average total costs (AC)	Qualitative: only data for primary plastics, prices of PP and PE products are above the average unit costs, see UBA (2024) and IN (Indicator) 15 in Table 19. Quantitative: degree of competition depends on the type of plastics products (Wieselhuber & Partner GmbH 2016).	n.a.

Note: n.a.: no assessment possible; IN: indicator number

The market of primary plastics comprises large suppliers in NACE 20.16 (Figure 11, and UBA (2024)) that offer PE and PP pellets to many SME plastics processors in NACE 22.2. In 2020, a total of 3,020 companies were located in Germany; of these, 92% were companies with less than 250 employees, which were responsible for about 60% of the turnover (Destatis 2020a). Many SMEs are usually key **customers** of PE/PP products. But also a few large companies with integrated plastics processing produce consumer products[9].

Table 14: Cracker Capacity in Germany in 2015

Company	Location	Total nameplate ethylene capacity, tonnes/year	Typical feedstock or feedstock mixture on which listed capacity is based, %				
			Ethane	Propane	Butane	Naptha	Gas oil
Basell Polyfine GmbH	Wesseling	738,000			10	90	
Basell Polyfine GmbH	Wesseling	305,000					100
BASF AG	Ludwigshafen	420,000		5	5	90	
BASF AG	Ludwigshafen	200,000		5	5	90	
BP Gelsenkirchen	Gelsenkirchen	576,265		2	12	73	13

[9] E.g. CDs from BASF

Company	Location	Total nameplate ethylene capacity, tonnes/year	Typical feedstock or feedstock mixture on which listed capacity is based, %				
			Ethane	Propane	Butane	Naptha	Gas oil
BP Gelsenkirchen	Gelsenkirchen	484,000	1	1	11	64	23
INEOS	Dormagen	550,000				100	
INEOS	Dormagen	544,000				100	
LyondellBasell	Munchsmunster	320,000	13	17	17	53	
Dow Chemical Co.	Bohlen	560,000				100	
OMV Deutschland GMBH	Burghausen	450,000	2.5	6	6	84	1.5
Klesch-Gruppe	Heide	110,000					
Shell & DEA Oil GMBH	Wesseling	500,000					
Total Germany		**5,757,265**					

Source: Leena Koottungal (2015)

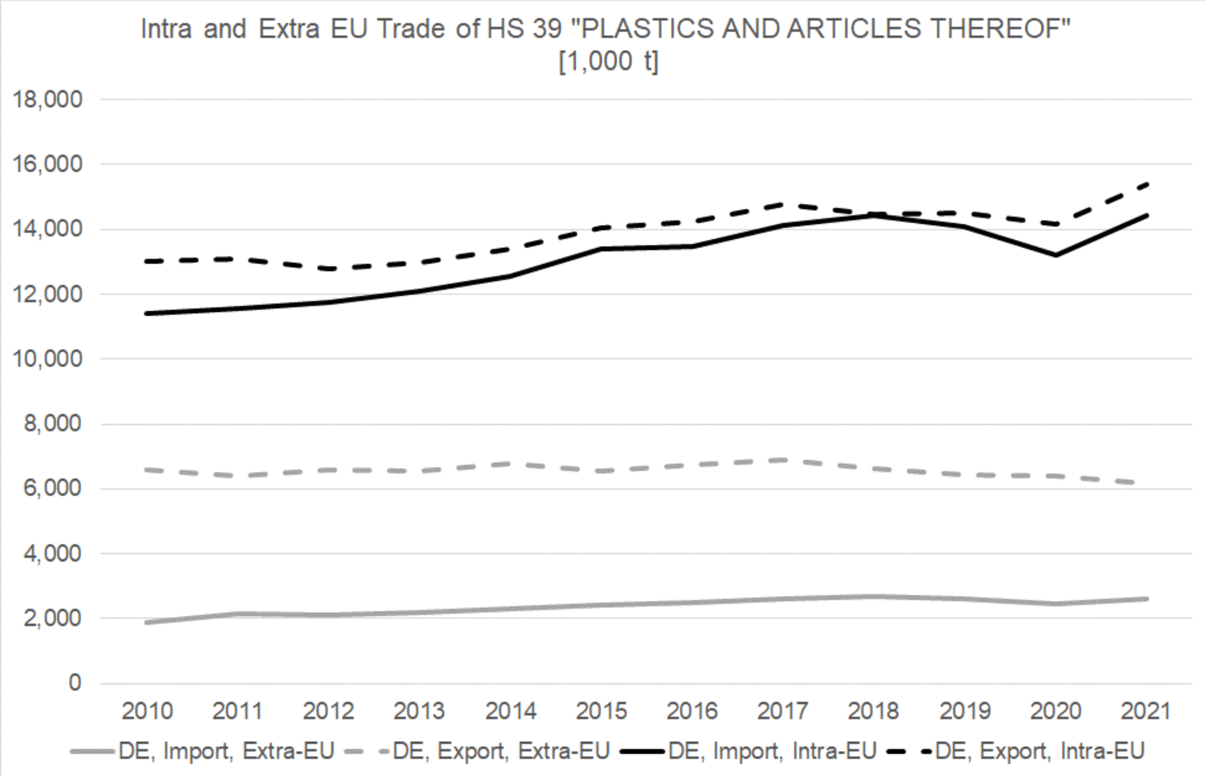
Regarding the variety of customers in Germany 2018, approx. 55%, of the rubber and plastic products (NACE 22) was traded on the domestic B2B market (e.g. the company Rehau manufactures bumpers for the automotive industry (KiWeb 2022a), and of these 9% are even further processed within the plastics industry. Only a small share, 6%, is traded at the B2C market (e.g. Gardena produces garden products), while 40% is traded at the global market (exported), of which 27.8% is delivered to EU member states (Destatis 2019a). Overall, the plastics (primary and products) market is a mature market.

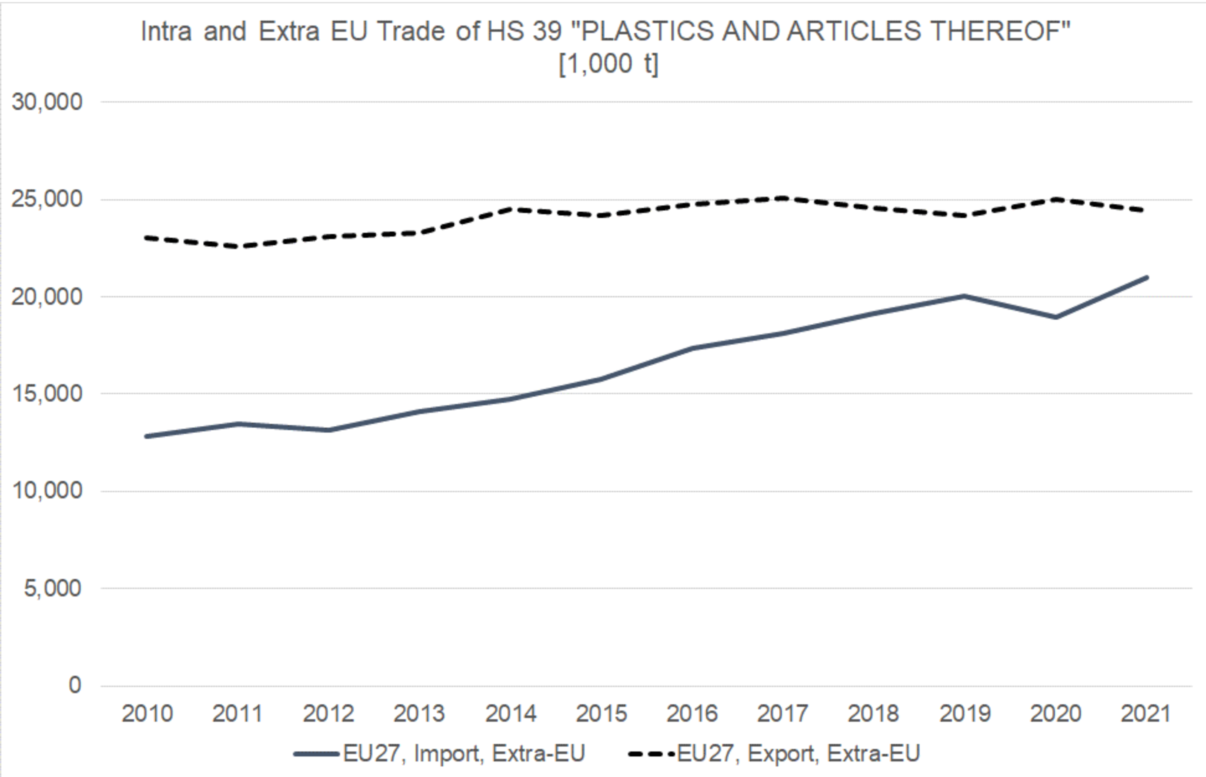
In 2015, three large sectors accounted for about 69% of PP and 84% of PE of total demand of final plastic products (NACE 22.2) in Germany. These are first the packaging sector (demanding 44% of PP and 66% of PE), second building & constructions (PP: 9%, PE: 14%) and third the automotive industry (PP: 16%, PE: 4%) (Consultic 2016).

Using Data from the German Input-Output Statistic for 2018, the production of the sector "rubber and plastic products (CPA 22[10]) was 114,688 million euros. The German export share was overall 40% (45,880 million euros) and 27.8% (31,870 million euros) is exported to other EU countries (Destatis, 2023). This reveals a high activity on the European and the **international market** as well. According to a study by Wieselhuber & Partner, the competition from imports of plastics products is growing, as competitors have diminishing market entry barriers such as proximity to customers and reliability of service through the establishment of European branch offices (Source: Eurostat (2022)). However, at the EU level, imports as well as exports display a growing trend, and net exports show no trend (NACE 22.2, see Figure 13 and Figure 14). In line with this, the German import surplus of PE- and PP products in the years up to 2017 declined due to a growth in exports, and fluctuates around zero since then.

[10] CEPA 22 is the equivalent of NACE 22, CPA is the statistical classification of products by activity

Figure 13: Foreign trade in plastics for Germany and the EU[11]





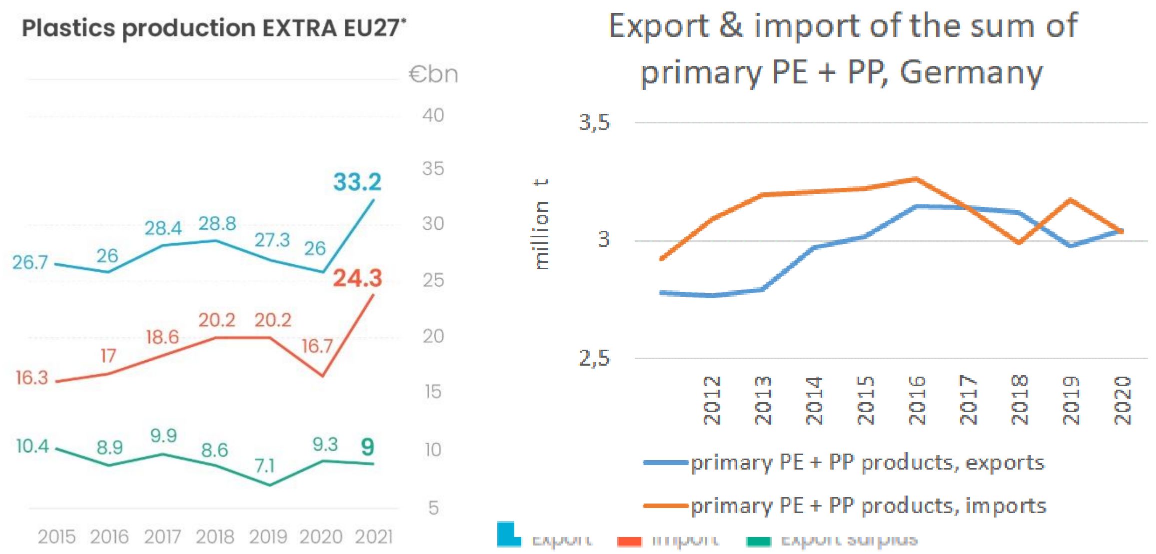
Source: Eurostat 2022

As can be seen, especially on the EU level, external imports have increased from around 13 Mt in 2010 to more than 20 Mt in 2021. EU-external exports, starting from nearly double the import value,

[11] Note: EU trade since 1988 by HS2-4-6 and CN8.

have only slightly increased. For comparison: Plastics Europe reports primary production of plastics for the EU in 2010 at 57 million tonnes, for 2021 at 50.1 million tonnes (Plastics Europe 2021, 2011). For Germany, total plastics production in 2021 (incl. adhesives, paints and varnishes, etc.) was around 21.1 million tonnes (2010: approx. 18.6 million tonnes) (Plastics Europe 2021, 2011). In Germany, a very modest increase of imports from outside the EU can be seen, while exports have also been roughly stable, slightly narrowing the net export balance. Furthermore, it can be seen that Germany's intra-EU trade is much larger than the EU-external trade, both for the exports and – even more pronounced - for the imports.

Figure 14: Imports and exports of plastics products and selected primary plastics



Source: PlasticsEurope 2022, Destatis 2022
Note: Export and import of primary PE and PP in Germany encompasses product groups WA390110, WA390120, WA390210 of Aus- und Einfuhr, Warensystematik Genesis Datenbank; specification of data sources[12]

The primary plastics Polyethylene and -Propylene are not completely **homogenous**, as they differ by the length of their carbon molecules, molar mass distribution and branching type. Some main groups for polyethylene are: HDPE (high density polyethylene) >= 0.94g/cm^3, PE-LD (low density polyethylene) < 0.94g/cm^3, and LLDPE (Linear low-density polyethylene) < 0.94g/cm^3. In the automotive industry, products made of the polyethylene grades HDPE are used to replace steel in gas tanks and LDPE / LLDPE are used in vehicles primarily in the engine compartment. The most important area of application for PP in vehicle manufacturing is the bumper/lighting sector (Plastics Today 2020). Furthermore, the prices indicated in UBA (2024), suggest some product differentiation. Overall, the markets are considered as mature markets with established processes and actors (Wieselhuber & Partner GmbH 2016).

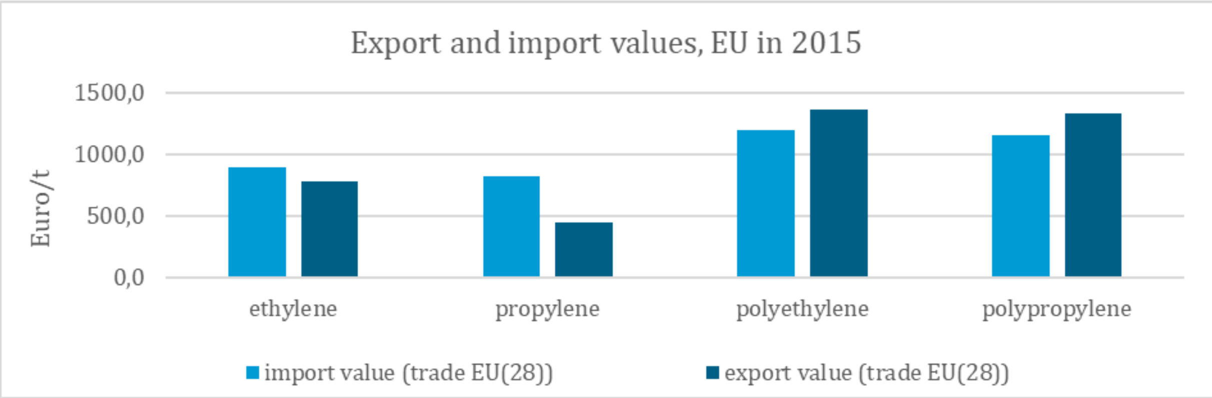
Prices of the different PE/PP products differ depending on the product characteristics, i.e. prices are high for special products, but low for mass products like tubes; the latter face a strong price competition. Furthermore, the value between imports and exports differ, i.e. global prices are lower than domestic prices for ethylene and propylene[13] (input for PE/PP), while the PE/PP pellets (NACE

[12] Source: left: (NACE 22); right: primary PE/PP products: WA390110 Polyethylen, Dichte < 0,94 in Primärformen, WA390120 Polyethylen, Dichte >= 0,94, in Primärformen, WA390210, Polypropylen in Primärformen, WA390760.

[13] Ethylene and propylene are usually processed directly. However, in 2015 there was some foreign trade (see Figure 15). Ethylene and propylene were imported, for example, from Norway (ethylene: 141,000 t, propylene: 81,125 t), but ethylene was

20.16, e.g. PE-LD in film quality and PP for injected moulding, NACE 20.16) achieve higher prices on the global than on the domestic market (Figure 15).[14] The findings suggest that some domestic companies seem to be able to realise higher prices for special products on the global market.

Figure 15: Export and import values of EU 2015



Source: own calculation based on trade volume in euros, Eurostat 2020b[15]

Average unit costs are not available for PE and PP products separately. Further, there exist a variety of market prices for different product densities or viscosity of PE and PP. Therefore, it is not possible to compare average unit costs to market prices. Overall, the indicators suggest that a certain potential exists of passing through higher costs, but it is unclear to what extent and share of primary plastics production this applies.

Market structure

Table 15: Overview on indicators of market structures in PE and PP

Aspect	IN	Level	Indicator	Findings	Passing-through
Market size	5	Global, EU, national, local	Market and prices in €/t,	PlasticsEurope, 2020*: Global primary plastics market with spot and future contracts Regional primary plastics markets: Asia (mainly China), North America, Europe, Middle East Africa)	Large markets -> price takers: -

also imported from the USA (64,279 t) and the UAE (50,330 t). Propylene also came from Russia (66,646 t). Exports were made to Switzerland, among others (Eurostat, 2022).

[14] The year 2015 was a year in which spot prices for propylene were significantly lower than for ethylene. In other years, the prices are about the same. Ethylene and propylene were imported significantly more than exported in 2015 (see UBA (2024). The import of polyethylene and polypropylene was slightly larger than the export.

[15] PRODCOM Codes: 20141130 (Ethylene), 20141140 (Propylene), 20165130 (PP) and for PE mass-weighted prices of 20161035 (Linear PE < 0,94 g/cm3), 20161039 (PE < 0,94 g/cm3 excluding linear PE) and 20161050 (PE · 0,94 g/cm3)

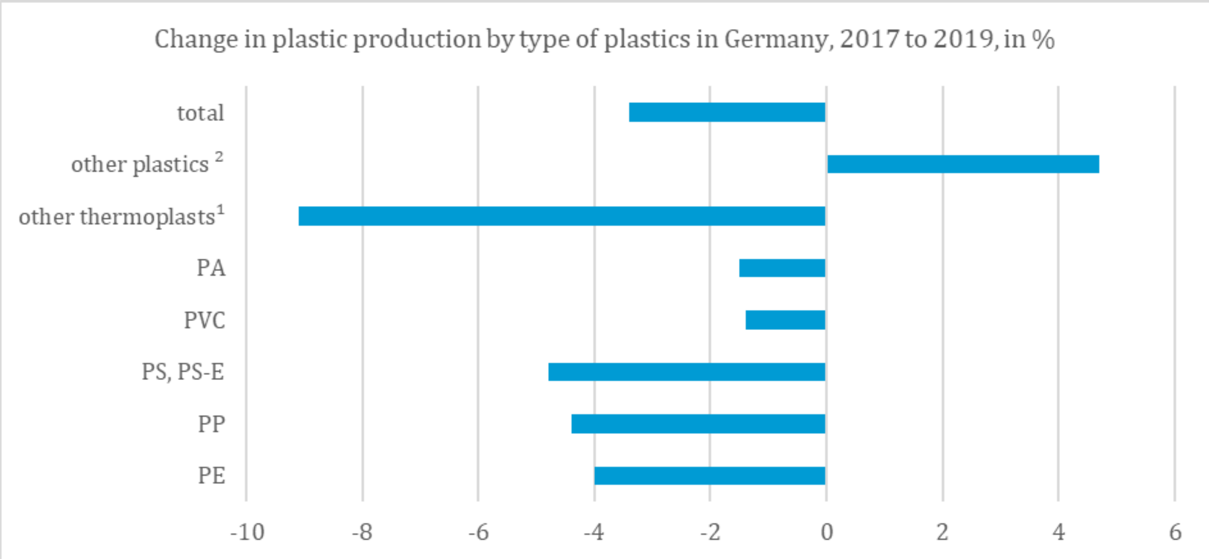
Aspect	IN	Level	Indicator	Findings	Passing-through
Market participants	6	Global, EU	Numbers of producers	Number of companies in NACE 20.16, Eurostat, 2019: EU: 2330 DE: 400 Number of companies in NACE 22.2, Eurostat, 2019: EU: 47.300 DE: 6260	NACE 20.16: + NACE 22.2: -
Market share	7	Global, national	% of top 5 (global) % ranks (Germany) % export share to global exports for EU, Germany	NACE 20.16: global top 5 producers: no shares available; Large globally acting companies are Lyndellbasell Industries, Celanese or DuPont top 10 in GER cover 52% of sales (Destatis, 2016) exports: trade shares not available, but Germany is a major exporter in the EU, see Figure 14), ***(NACE 22.2): GER top 3**: Würth GMBH & Co. KG, Freudenberg SE, Röchling SE & Co. KG, all producing a variety of plastics products; top 10 in GER cover 18% of sales (Destatis, 2016)	NACE 20.16: - NACE 22.2: n-a-
Market entry, market exit	8	Global or EU	Number per year (or each 2, 5 or 10 years)	Number of manufacturers, Eurostat SBS 2011-2020 variation in primary plastics (20.16): changes between consecutive years range between -14 and +18% in Germany, and -3 to +5% in the EU variation in plastic products (22.2): changes between consecutive years range between --7 and +6% in Germany, and -3 to + 4% in the EU	NACE 20.16: EU: n.a. GER: - NACE 22.2: EU: n.a. GER: (-)
Intensity of rivalry	9	Global Germany	Yes/no, examples Sales (€) or production (t) over time	Turnover of manufacturers, Eurostat, SBS 2011-2020 variation in primary plastics (20.16): Germany between -25% to +14%, EU between -11% to +6% variation in plastics products (22.2): Germany between -5% to + 12%, EU between -4% to + 6%	NACE 20.16: EU: -. GER: - NACE 22.2: EU: (-) GER: -

Note: n.a.: no assessment possible; IN: indicator number; * https://plasticseurope.org/wp-content/uploads/2021/09/Plastics_the_facts-WEB-2020_versionJun21_final.pdf, ** https://www.listenchampion.de/produkt/liste-der-groessten-kunststoffverarbeiter-in-deutschland-inklusive-umsatz/, *** https://blog.bizvibe.com/blog/plastic-manufacturing-companies.

The market structure is depicted by the scope of the market, number of market participants, market shares and market entries and exits. PP and PE products are globally traded in spot and forward contract **markets** where many suppliers and customers competitively agree the volumes and prices traded in the present and future. As a result, price competition prevails while price setting opportunities are very limited, especially when forward contracts are traded. Large regional markets are in Asia, mainly China, in the NAFTA countries, Europe and Middle East Africa.

Regarding the market growth, primary plastics[16] production is decreasing in the EU (28+NO and CH), with an annual production of about 55 million tons (2020), while it is increasing worldwide with 367 million tons in 2020 (Plastics Europe 2021), see Table 13. In Germany, the production of PE/PP products has declined as well by about 4% (2017-2019) as illustrated in Figure 16. Globally, demand for plastics products is expected to growth further, which offers space for new businesses and actors. This strong demand is also reflected in the EU, where demand exceeds production.

Figure 16: Change in primary plastics production in Germany by type of plastics ([1] e.g. PET, ABS, ASA, SAN, PMMA, PC und POM; [2] e.g. PUR; PE)



Source: Statista 2022, Conversio 2020

The share of the EU in global plastics production is about 15% in 2021, see Table 16. The plastics processing industry (NACE 22.2) encompasses about 55 thousand companies in the EU (Eurostat), a large share of them are SME's. In Germany, about three thousand firms, mostly SMEs, produce plastics products (NACE 22.2). Therefore, this pure number of companies suggest that there is a high competition.

With respect to global market actors, survey results by Wieselhuber & Partner (2016, p. 27) showed that 94% of respondents cited other EU firms as "highly relevant" competitors, another 89% named Asian/Chinese competitors, a further 87% pointed to Turkish competitors and another 69% to North American firms (and a further 48% to the "Rest of the World") in 2015. We have not obtained data for recent years on this finding.

Between 2011 and 2020, the number of plastics processing companies (NACE 22.2) has declined in Germany and the EU (27), while there has been an increase in the number of primary plastics producers (NACE 20.16) in a few countries, such as Poland or Romania, and the EU in total, signalling a highly competitive market (Figure 16). Especially in Poland, the increasing number of companies

[16] Polyethylene (PE), Polypropylene (PP), Polyvinyl-chloride (PVC), Polyethylene Terephthalate (PET), Polystyrene (PS), Expanded polystyrene (EPS), ABS, SAN, Polyamides (PA), Polycarbonate (PC), Poly methyl methacrylate (PMMA), Thermoplastic elastomers (TPE), Polyarylsulfone (PSU), Fluoropolymers, PEEK, POM, PBT, EVOH, etc.

suggests that new competitors are emerging that might benefit from cost and efficiency advantages such as new production technologies and business models (SBS). Therefore, Poland's chemical and plastics industry has been booming in recent years due to increased foreign and domestic investment (KiWeb, 2021). In Germany, the up and down in the number of market participants - decline of production value per site (primary PP and PE) between 2019 and 2020, and the subsequent increase in 2021 (Destatis 2022) - indicates a potentially intensifying competition in the market. The reasons why the number of primary plastics producers in the EU is increasing while the number of plastics processors is decreasing have not been found in the available publications.

Table 16: World Plastic Production and European Plastic Production (NACE 20.16) [million tonnes][17]

Year	World production	Europe production	Europe's share [%]
1950	1.7	0.35	21
1976	47	19.8	42
1989	99	27.4	28
2002	204	56.1	28
2008	245	60	24
2009	250	55	22
2010	265	57	22
2011	279	59	21
2012	288	59	20
2013	299	57	19
2014	311	59	19
2015	322	58	18
2016	335	60	18
2017	349	64.4	18
2018	359	61.8	17
2019	368	57.9	16
2020	367	55	15

Source: PlasticsEurope

The average size of primary plastics producers (NACE 20.16) is about 59 employees per company for the EU (27) in 2019, 116 employees per company in Germany, and about 30 in Poland (2022, Eurostat SBS). Known trade names of PE/PP plastics are Hostalen, Lupolen, Ateva or Bynes. They are offered by large globally acting companies such as DuPont, Lyondellbasell Industries or Celanese. In contrast, plastic processing companies (NACE 22.2) are mainly small companies, as the further processing of PE/PP products requires less capital-intensive investments and plants. The average size of producers is about 30 employees in the EU27 (2019), 54 employees per company in Germany (2021), and about 22 employees in Poland (Eurostat).

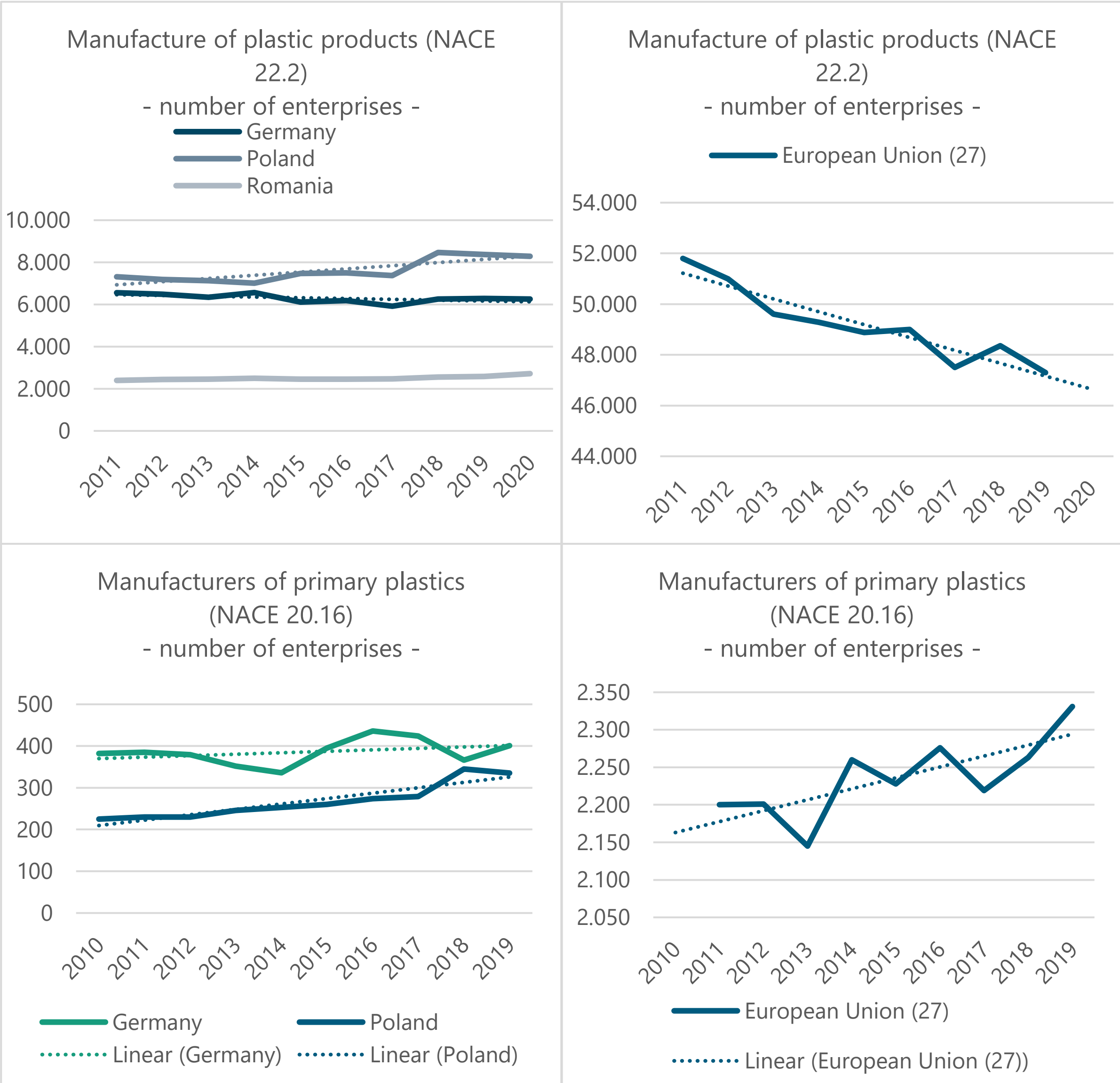
[17] The data for 2021 are not shown here because they are not comparable (different delimitation: with secondary and bioplastics, without coatings, sealings etc.).

Some plastics producers are integrated in larger companies, for example in the conglomerate of the Würth GmbH, or the automotive supplier Freudenberg or the plastics processor Röchling SE & Co. KG. Only a share of the total turnover of these types of firms derives from plastics production and since no company-internal production figures of PE/PP products are available in the statistics, specific market shares of individual PE/PP or plastics producers, or shares of different company sizes, are not available.

The market for processed plastics products can be characterized by small producers facing large customers at the demand side. The small producers are in general price takers and not price setters, whereas some might also act under monopolistic competition. However, no data or other qualitative information is available. Therefore, it is assumed that, in general, the small producers have to accept the price offered on the market and are not in a position to determine the price or factor in additional costs, except producers have special customer relationships based on long-term contracts or are even integrated into the final product manufacturers. In general, such price takers are particularly affected by the differences in costs between the regions.

In addition to the development of firms over time, the annual change in the number of firms provides a rough estimate for **market exits and entries** and thus an indicator for competition. In the primary plastics production, changes are high for Germany, and low for the EU, in plastics products, they are low for both, Germany and the EU (Figure 17). This supports, although less strongly than the development of sales over time, a competitive market in which passing through of costs is challenging.

Figure 17: Number of manufactures in primary plastics and plastics products



Source: Eurostat, SBS

Market shares of the top 10 producers of primary plastics and plastics processors confirm the findings from above. They reveal a higher concentration of market power in the primary plastics production (2016), where 10 producers cover about 52% (2016) of the sales in Germany, while it is 19% for plastic processors (NACE 22.2) (Destatis). The market shares of primary plastics producers imply an oligopolistic market, where competition is as strong as in a polypolistic market, because the PE and PP pellets are traded globally and none of the producers is large enough to determine the price. As a result, the chances to pass through higher costs are very small even for companies with higher market shares.

Prices – spot and contract prices – are volatile. Between January 2020 and June 2022, the average monthly contract prices show an upward trend leading almost to doubling of prices. The differences between the minimum and maximum prices and the average price (contract prices) over this period are around – 38% and 44%, respectively (Table 17). This points to a volatile market offering some opportunities for price hedging and fewer opportunities for cost pass-through.

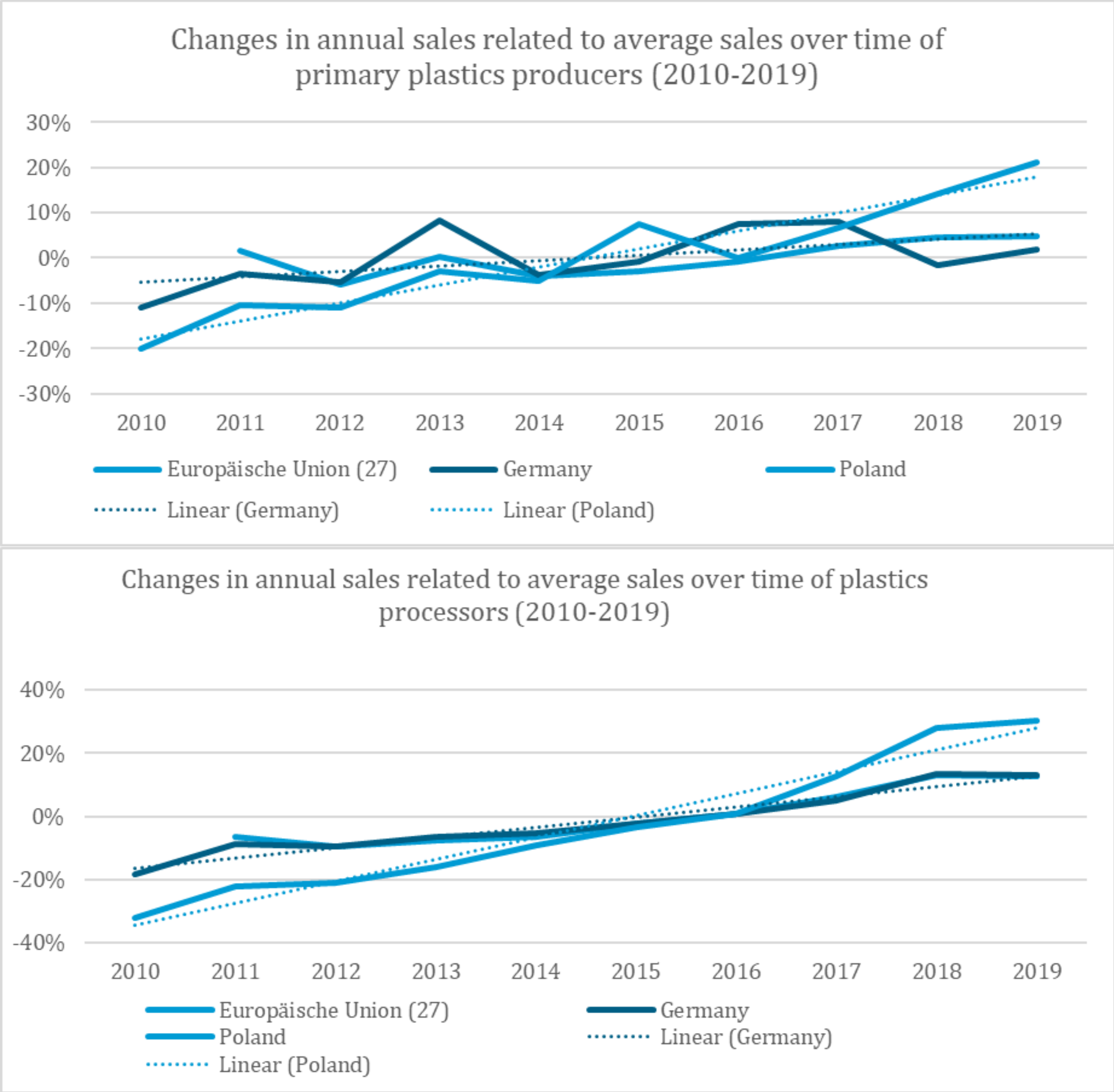
Table 17: Price changes over time (2020 - 2022)

	PE-LD	PP Homopolymere
(Jan. 2020 – Jun 2022, monthly prices)	EUR/t	EUR/t
mean	1,729	1,723
std	468	470
min	1,078	1,063
max	2,420	2,480
% diff of min and mean	-38%	-38%
% diff of max and mean	40%	44%

Source: own calculation based on KI Kunststoff-Informationen 2022, contract price

When looking at the sales of the primary plastics industry (**intensity of rivalry**), the annual variations in sales (sales related to a 10 (9) year average) are higher for Germany than for the EU27. Poland shows even larger changes (sales and number of companies), but with an upward trend, while for Germany the slope of this trend is very small. For plastics processors, sales are tending to rise, particularly in Poland. Changes in sales in consecutive years are relatively high for primary plastics production in Germany, while for the EU they are lower. Similarly, variations in sales of plastics products are higher in Germany than for the EU, but lower than for primary plastics. Overall, the sales variation indicates a rivalry, in particular, in Germany for both (NACE 20.16 and 22.2), less for the EU. Plastics products have revealed a growing trend between 2014 and 2021, followed by a small decline in 2019 and 2020 (PlasticsEurope 2022). Overall, it is expected that the growth trend in demand at global and European market will continue. Although some indicators point to a competitive market situation, to some extent passing through of cost increases might be feasible in light of growing demand.

Figure 18: Changes in sales of the primary plastics producers[18]



Source: own depiction based on Eurostat 2022 Production of primary plastics and plastics processors, nominal values.

[18] Note: NACE 20.16 and NACE 22.22, average price is based on 2010-2019

Business Environment

Table 18: Overview on indicators of the business environment in PE and PP

Aspect	IN	Level	Indicator	Findings	Passing-through
Integration	10	German com-panies	% of produc-tion/sales per type (I, L)	no information on the degree of integration	NACE 20.16: n.a. NACE 22.2: n.a.
Substitutes	11	Global	Yes/no actual or hypothetical substitution	Yes and no: in many applications no substitutes of plastics products (22.2), but in some applications wood or metal are an alternative Biopolymers are used but higher costs, currently market share at 1-2% (k-Zeitung 2020, KiWeb 2016)	NACE 20.16: n.a. NACE 22.2: (-)
Sales market	12	Global	Number of automotive customers Alternatives: yes/no; brief description	Use of primary plastics and plastics products in several sectors (2022): packaging 31% , construction 38%, technical parts 21%, final consumption10% (GKV, 2023); See indicator 12 in Table 10; See illustrations in UBA (2024). NACE 2016: Small number of primary plastic producers face a large number of plastics products producers (see indicator IN 6 in Table 15); NACE 22.2: Share of automotive industry is small compared to the others (9,6% of plastics products (in t) to automotive sector in 2019, PlasticsEurope 2020)	NACE 20.16: + NACE 22.2: +
Product innovati on	13	German companies	Yes/no	Know-how-intensive and precise use of equipment required; no patents possible on formulations of chemicals	-
Process innovation	14	German companies	Yes/no	Processes in fossil primary plastics and plastic products are mature, if innovations, then incremental. Further innovations are to be expected in processes for decarbonisation: bio-based polymers, electrothermic processes, etc. (Geres et al. 2019)	-

Note: n.a.: no assessment possible; IN: indicator number

Regarding the degree of **integration**, data is hardly available. In 2015, the availability of basic polymers became an issue and questioned the future reliability of polymer suppliers. At that time, the majority of plastics processing companies were not expecting any improvement in the supply situation, according to a survey (Wieselhuber & Partner GmbH 2016). While large, multinational companies evaluate options for global sourcing towards upstream industries, small producers, i.e. the majority of European producers, are less flexible and will continue to face challenges regarding their competitiveness coming from less reliable supplies (Wieselhuber & Partner GmbH 2016). In contrast, plastics production that has been integrated in larger conglomerates or B2C manufactures could internally be cross-financed by other production units, and, thus might be able to stay longer in the market.

Regarding the downstream companies **(sales market**), the automotive sector is an important sales market, but others, such as the packaging and building sector, are even larger sales markets for the plastics industry (GKV 2023). Thus, lacking demand from the automobile sector might be compensated to some extent by other sectors as the primary input (PE or PP) is rather homogeneous. However, although the plastics processing methods for the products of the different industries are the same, the know-how of the processors lies mainly in the unwritten formulations of the plastics compounds and the knowledge of the different requirements of the different markets. The plastics processing industry is a polypolistic industry with many small companies that faces an oligopolistic automobile industry, with large companies (mainly three in Germany) that belong to the top 50 of this sector (Wieselhuber & Partner GmbH 2016). Thus, the negotiation position of the plastics producers dealing with the automotive industry is not strong, especially if they are not integrated in a group of companies. In addition, competitors from Asia and China are seen as currently highly competitive and are expected to become even more competitive with respect to the automotive sector[19] such that domestic producers might lose market shares.

In the past, plastics have replaced wood and metals in many applications due to their favourable characteristics. This development could theoretically be reversed **(substitution)**. Arguments against turning away from plastics in automotive construction include the facts that they are used also for safety considerations and for reasons of lightweight construction. Alternatively, biopolymers are seen as potential substitutes, but so far their production cost is still high. Their current market share is about 1-2%, but it differs by the type of applications (KiWeb 2016, k-Zeitung 2020).

In addition to new materials, recycled plastics could become more important, at least in the EU due to the EU plastics strategy, among other things. It is therefore likely that recycled plastics will be increasingly used in the future, saving primary goods and resources. To what extent, however, this is even feasible with high-quality or safety-relevant products such as e.g. bumpers in cars is still unclear. So far, about 5.5% of plastics used in the automotive sector stems from recycled plastics (Conversio 2020). Suppliers of secondary plastics, so called "regranulates", are often also primary plastics suppliers. Demand for regranulates depend on the quality-price ratio, but also on regulations or standards for final products.

Polymer mixes cannot be protected through patents **(innovation)**. Therefore, product innovations are mainly dependent on technological innovations of processes that open the window for the creation of products. Since plastics processing requires detailed know-how, very precise handling of the machinery, mainly marginal changes of products, hence, product innovations are feasible. Theoretically (and in practice), such improvements can imply gains from product differentiation to the innovating firm and thereby enhance the potential scope for passing-through input costs such as CO_2 costs embedded in the production inputs. At the customer side, the transformation of mobility from fossil fuel to electricity-based energy carriers might entail new plastics components. A similar role of innovations is proposed by Wieselhuber & Partner (2016) for the plastics products industry, in which product innovations, often developed together with the customers, play a major role in the strategies to maintain a competitive edge versus importers. Ties with customers even

[19] Wieselhuber & Partner GmbH, 06/2016

play a relevant role in decisions to export the own products, which are often undertaken only if major customers set up new export (or foreign production) activities (ibid.).

Regarding the extent to which higher costs are passed through, we have arrived at contradictory findings. Together with the weak data and information on the specific sector, we are not able to conclude whether price pass-through is feasible or not.

Product features

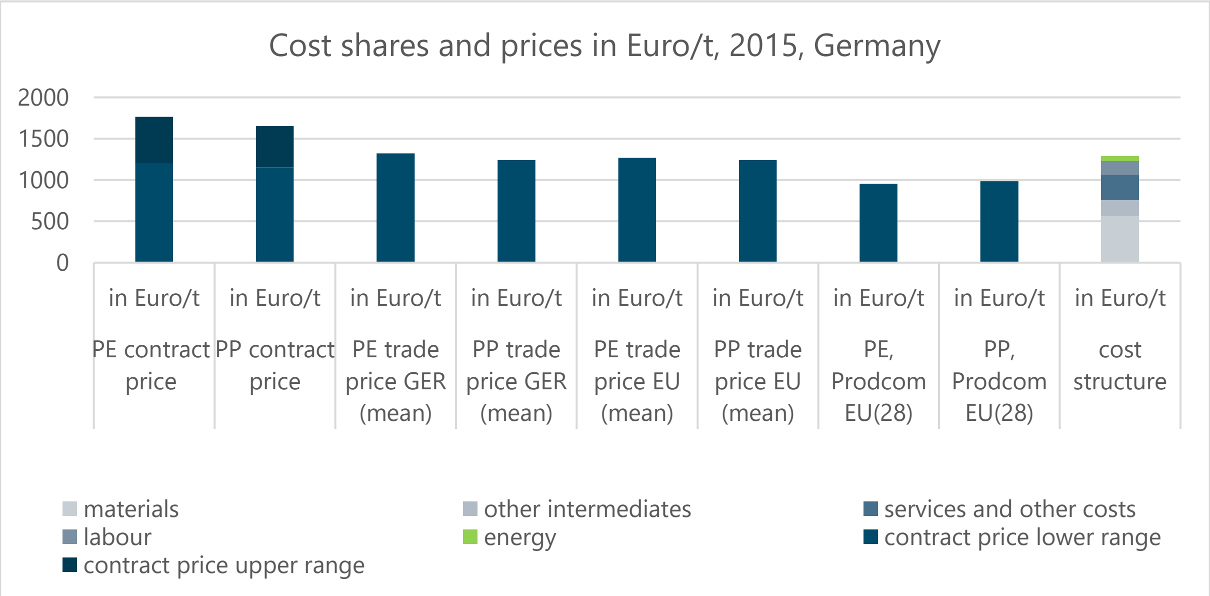
Table 19: Overview on indicators of selected product features in PE and PP

Aspect	IN	Level	Indicator	Findings	Passing-through
Cost shares	15	EU, Germany	€/t	Cost components of primary plastics (20.16) see UBA (2024). Unit costs are highly variable since they depend on inputs with very volatile prices (see UBA (2024). Assessed average unit costs of PE and PP: €1287 /t, see Annex D.1 Prices of primary plastics (20.16): range between €955 and €1765/t (PE) and €985 and €1650 (PP)/t, in 2015, see UBA (2024). Emission factors 0.35 t CO_2/t, see UBA (2024).	Low share of energy: +
Price dependency of demand	16	Global, EU, Germany	Time series of prices (€) and sales (t)	PE and PP (Eurostat, Prodcom): trend of increasing import volume with declining import values points to a certain price sensitivity	-
Transport costs	17	EU or Germany	€/t km	Differing price developments across regions and modes of transport, but small compared to total costs*	n.a.
CBAM	18	EU	Yes/no	no	-

Note: n.a.: no assessment possible; IN: indicator number; * KiWeb (2022b)

When looking at the direct inputs of PE/PP products, materials (ethylene or propylene) play a key role in costs while the **cost share** of energy input is small (below 5%). However, the production of the input material ethylene and propylene is very energy intensive, while the polymerisation (PE or PP) requires no or a low level of energy input such that that the processes are often integrated. Figure 19 displays different prices to emphasis their large range. Further, the displayed unit costs may vary as well, because it strongly depends on highly volatile ethylene and propylene prices. All prices and costs refer to 2015. Overall, depending on the realised market price, primary plastics producer might earn a margin or make a loss per tonne of primary plastics product.

Figure 19: Prices of PE and PP pellets and costs by input

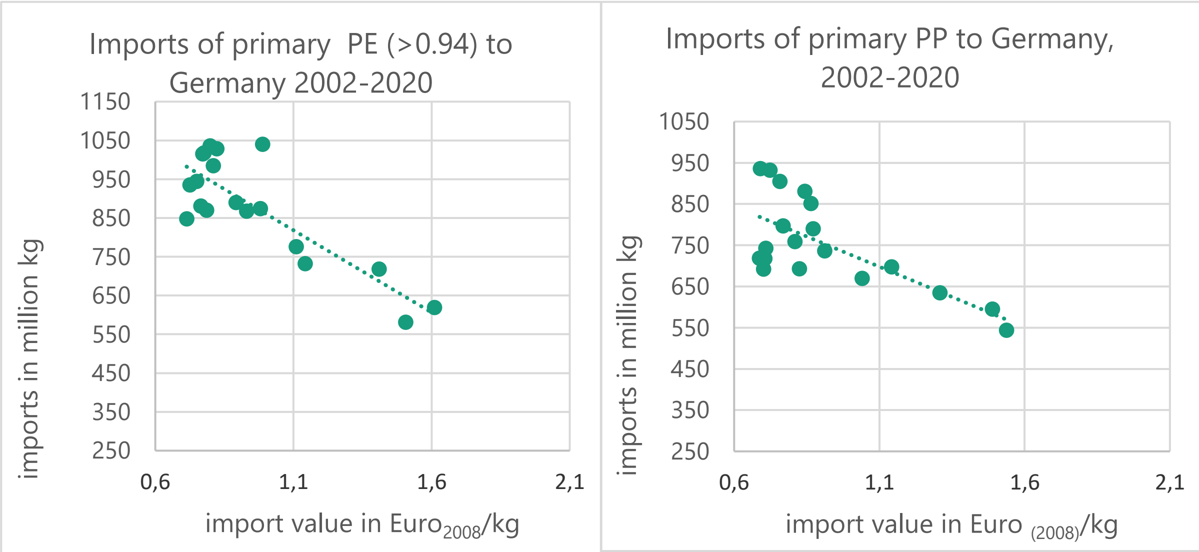


Source: own depiction based on data from UBA (2024), and Table 20

Transport cost are currently rising due to the Ukraine-Russia war, and range around 12,500 USD (11,365 EUR) for a standard 40-foot container from China to Northern Europe. For the opposite direction, 950 USD (865 EUR) was being charged for the container (KiWeb 2022c). With rising transport costs, PE/PP pellets from e.g. the US become less competitive, allowing domestic producers to pass through a larger share of their energy or CO_2 costs. However, the share of transport cost in overall costs seems to be small.

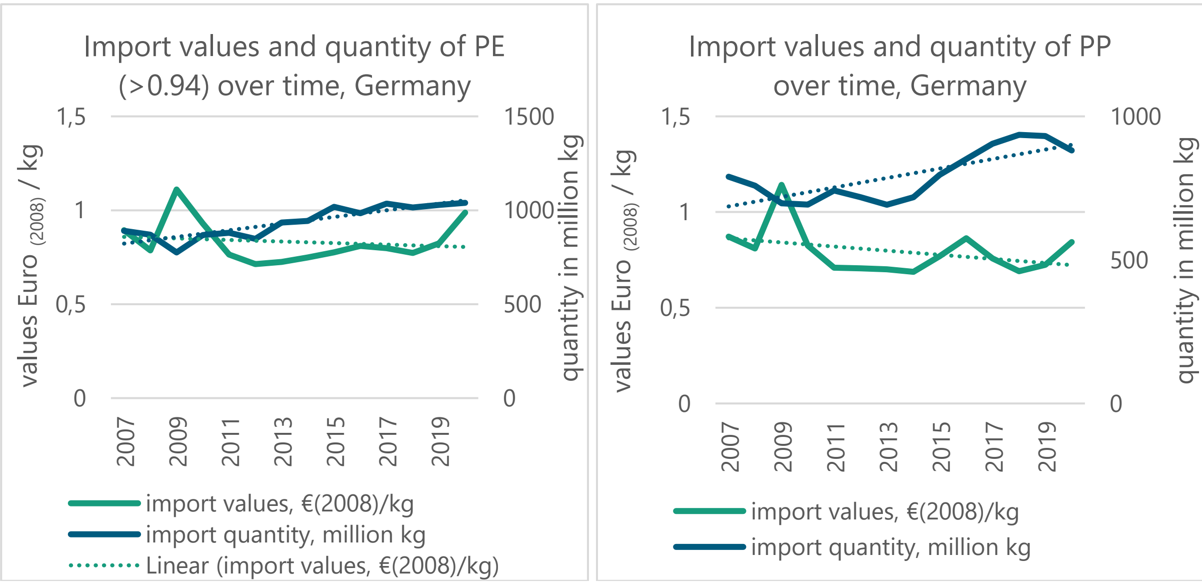
The relation of **prices and sales** is illustrated below, based on import values and quantities for two selected products, PE>0.94 and primary PP. For both products we find a linear relationship between prices and sold amounts suggesting a low inelastic demand for given demand levels, whereby a change in prices of primary PE results in a stronger decline of sales than for primary PP. The trend of import volumes and values is also illustrated in Figure 20. It shows a negative correlation for Germany and the EU.

Figure 20: Import values and quantities[20].



Source: own depiction, based on Eurostat,Prodcom

Figure 21: Import quantity and values over time.



Source: Eurostat, Prodcom.

PE/PP products are not covered by the first CBAM implementation stage (EC 2023). Consequently, relatively large free allocations - which cover the majority of CO_2 emissions in the production of the PE/PP precursors (Naphta/natural gas, and ethylene/propylene) - very plausibly will continue – at least for some years - to "shield" European producers from incurring high additional CO_2 costs in relation to their international competitors. At the export markets, if rather homogenous products such as PE/PP pellets are traded, they are mostly traded at global market prices. German or EU based PE/PP suppliers thereby cannot act as price setters at the global market but are price takers and thus pass through of additional CO_2 costs is not feasible under such global market conditions. In contrast, German plastics processors might benefit from this situation, as global and domestic

[20] Note: at prices of 2008; Note: linear relationship with an R2 of 0.5 and 0.7 respectively

prices of PP and PE merge without cross-border mechanisms and the market is then a global market.

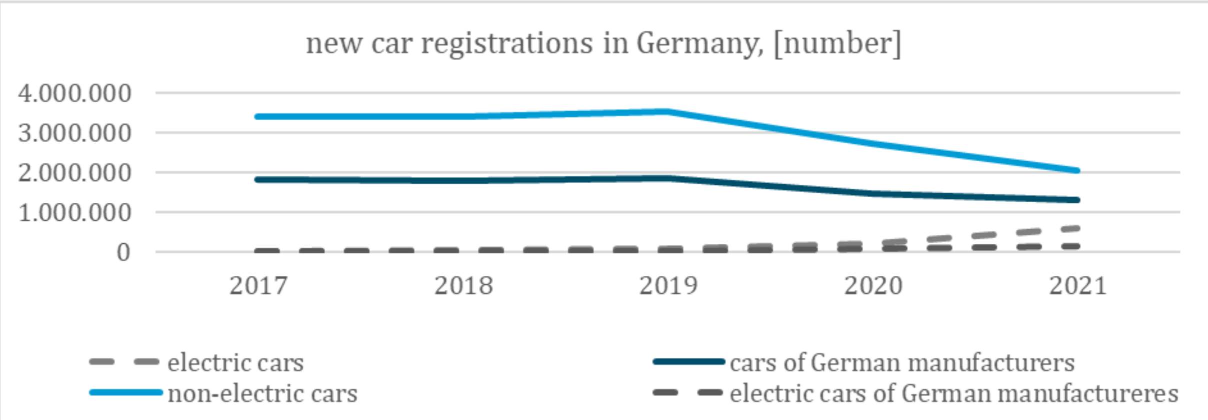
Overall, the picture of the market is not clear. Although some indicators point to highly competitive markets, other indicators underline a high dynamic and variety of market prices (and hence places) offering new opportunities and chances to cover all costs. However, higher CO_2 costs of domestic producers represent a competitive disadvantage if companies abroad do not face costs in similar magnitude.

3.3 Automobile sector

The automobile sector, as a highly relevant customer sector for both hot-rolled steel coils and plastics products, is itself briefly addressed in the following. One major argument for doing so is the proposition that the European and German automotive industry's own competitive situation (and market development in terms of sales and competition) plays a relevant role for its ability to pay higher prices to their steel or plastics suppliers as a consequence of prices shock on the suppliers' side. Since, the role of plastics in car manufacturing is expected to increase in the following years (Knauf Industries 2020), the competitiveness of the business clients becomes more and more an important precondition for plastics producers along the value chain to pass through potential cost increases.

The automotive industry and market is very heterogeneous in its products, and competitive at a global level. Further, the ongoing environmental concerns regarding air pollutants, the energy transition and the recent energy crisis (Russia-Ukraine war) have brought about a situation of upheaval in the automotive industry. This upheaval is accompanied by technological developments in the information and communication technologies and the energy transition (twin green and digital transition (Muench et al. 2022) potentially entailing new forms of individual mobility. The combustion engine of cars seems to disappear slowly, and electric cars are gaining (slowly) market shares. This development is depicted in Figure 22.

Figure 22: Registrations of cars in Germany



Source: own illustration based on data of the Kraftfahrt-Bundesamt

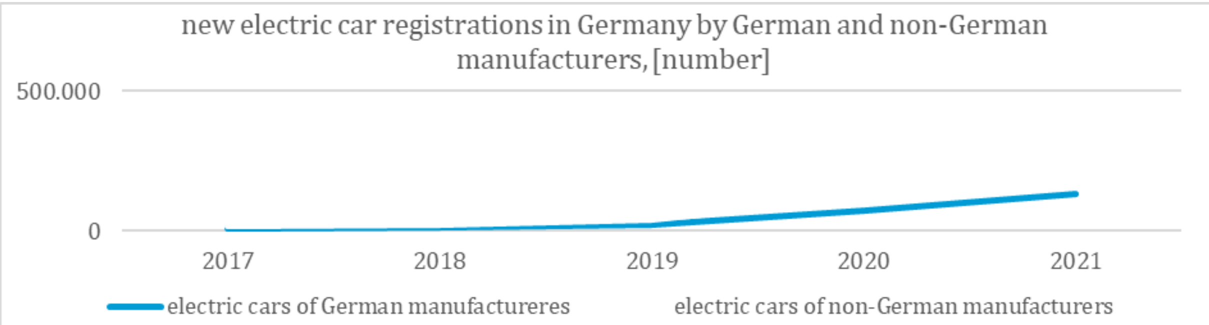
Furthermore, the car market is a highly competitive market, in which German manufacturers have to compete. The market share of German car manufacturers in Germany has increased during the last years, displaying a re-enforcement of their competitiveness. When looking at the electric car segment, the market shares of German manufacturers in Germany seem to be decreasing. However, an interpretation of the data differentiated into in combustion and electric cars is not yet meaningful due to the small number of observations and databases. Both developments are depicted in Figure 23 and Figure 24.

When assessing the CO_2 cost share of a BEV[21] (see UBA (2024)), and including CO_2 costs embedded in all analysed materials, the cost share might amount to about 1.6% for a medium-sized BEV at CO_2 prices of €100/t $CO_{2eq.}$ (see UBA (2024)). Figure 25depicts these cost shares of CO_2 for different materials of a BEV, and the total (all materials, including e.g. aluminium and glass) under the assumption of a CO_2 price of €100/t CO_{2eq}. These seemingly low costs imply that passing through additional costs to the final end user (BEV buyer) should not be a problem. However, given the challenging and changing environment in the BEV market, assessing the pass-through of additional CO_2 costs is challenging. As demand of conventional combustion cars is decreasing and of electric cars increasing, we assume that prices could be passed on in the latter segment. However, this assumption is not yet supported when we look at the weak market position of German electric car manufacturers in Germany with respect to BEV market shares in Germany.

Figure 23: Registrations of cars in Germany

Source: own illustration based on data of the Kraftfahrt-Bundesamt

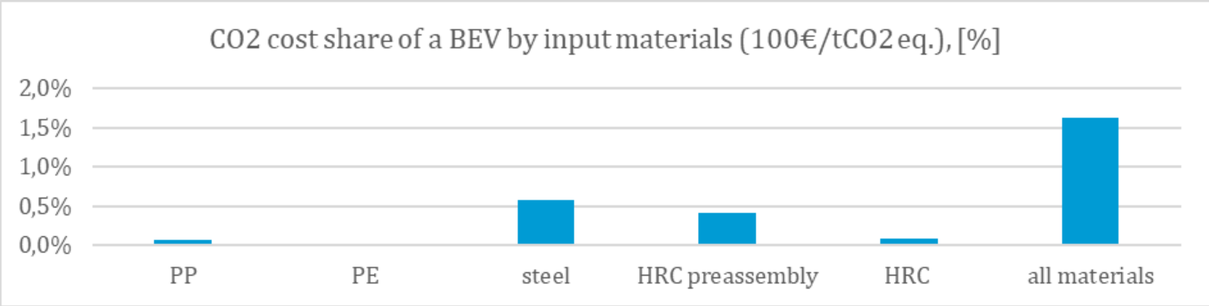
Figure 24: Registrations of electric cars in Germany



Source: own illustration based on data of the Kraftfahrt-Bundesamt

[21] Assumption: total price of a BEV car is 20,000 euros (small to medium size)

Figure 25: CO_2 cost shares in a BEV (€100/tCO_2eq)



Source: own assessment based on data from UBA (2024)
Note: data in UBA (2024), assumed CO_2 price of €100/t CO_2, BEV price of 20,000 Euro

4 Discussion and summary

The aim of this Section 4 is to assess to what extent higher costs induced by CO_2 prices can be passed through from the supplier of primary plastics and hot rolled coils to the respective customer, be it B2B or B2C. Based on selected indicators describing the competitive situation and market structures and business environment (see 4.1), an assessment of the potential of passing-through increased costs has been conducted. The findings in section 4.2 reveal that data to assess and describe the passing-through at the disaggregated level were hardly available. Further it became clear, that there are a variety of individual business relationships and market condition, making it impossible to make a clear statement on the passing-through potential of the NACE branches C20.16 and C24.1031. Therefore, the aim of this section is to highlight the variety of passing through potentials and account for the market dynamics by displaying ranges of passing through. This is done by illustrating the passing through potential of four different cases.

1) Integration and reference case (unit cost):

Hot rolled coil production is integrated in the automotive industry. In case the hot rolled coil production is part of the automotive industry, the complete unit costs (of all inputs, not only CO_2) can theoretically be fully passed on to the end product, but only internally. This leads to higher costs of downstream products, and weakens their competitiveness, especially if hot rolled coil could have been purchased at lower prices at the global market. Hence, the final cost pass-through of additional CO_2 costs depends in this case on the market position of the integrated automobile industry in the B2C market, i.e. the automobile market. This case 1 also serves as reference case for the other cases, as it depicts the full unit costs under a CO_2 price of €100/t CO_2.

2) Spot market - competition

In case hot roll coil producers sell their product on the global market, the price is the result of global supply and demand, i.e. the market price mechanism. Under a global, competitive market, the suppliers are price takers. Thus, regionally differing costs such as CO_2 costs cannot be passed on, since under full competition prices equal marginal costs. In the HRC spot market, prices range theoretically around the minimum average production costs of all competitors. In case suppliers are active in a closed internal market, i.e. they face no competition through imports and have no exports, and all suppliers face the same production conditions including cost increases, then theoretically, costs can be fully passed on while demand might decline. However, a closed market is far from reality and would not be beneficial for the welfare of a society. Instead, to leverage efficiencies in production and consumption, and hence, increase welfare, markets should to be open and accessible for all potential manufactures and consumers. The CBAM aims to create similar production conditions for companies within the EU and importers to the EU. Therefore, importers incur additional costs from purchasing import certificates that are directly linked to European CO_2 certificate costs. In principle, the CBAM acts in one direction, namely for importsCO_2. In contrast, exports of European products to the rest of the world are still traded at global market prices. Theoretically, rebates could be introduced to enable a "level playing field" also for exports from EU manufacturers in the sectors covered by the CBAM, but these are very contentious in the international area and could be challenged before the WTO. Without such rebates, the global market prices might only be affected by the CBAM in case many global producers adjust their production processes and reduce their CO_2 emissions as well. However, this would require among others a general agreement on standards, market regulation and markets for CO_2

3) + 4) Special relationships and contracts - indexing

Hot rolled coil producers could agree on a purchase contract with an automotive manufacturer. Such purchase agreements could include a price or price component that is indexed on production price indices (PPI) or other input markets such as CO_2 prices, or electricity prices. For example, electricity contracts with energy intensive industries partly base the contracted price on the PPI. Under PPI indexing, passing on of CO_2 prices is to a very limited degree feasible because CO_2 prices affect the costs of other manufactured products, and, hence, the PPI as well. The average share of energy cost per value added is about 6% (Öko und DIW 2016) in the industrial sector in Germany (2016). A production price indexed contract accounts only for a cost transfer of about 0.4% (6% x 7%) when assuming an electricity price increase by 7%[22], given a CO_2 price of 100 €/t. Another source reports that changes of CO_2 costs by one percentage result in electricity price changes of 0.075%[23], but it includes other input price increases as well. Overall, the PPI is an option that accounts for changes in CO_2 costs, but only to the degree as it is included through energy in the producer price index. We index the whole product price with the PPI index and assume - as outlined above - that an increase of the CO_2 price to €100/t entails an increase of the PPI by 0.4%.

4.1 Hot rolled coil

General findings

In 2020, the market of basic iron, steel and ferro-alloys in the EU and Germany is characterised by about 2770, respectively 460 manufacturers of basic iron and steel and ferro-alloys (Eurostat, SBS) on the supply side and a few large industries on the demand side, e.g. the automotive industry and the building sector. In the automotive industry, primarily HRC from BOF are used (for shares of HRC from BOF or EAF see UBA (2024)). HRC could be partly substituted by aluminium in certain applications in the automotive industry, but from a cost and environmental perspective, this is not better. Further, product differentiation is potentially feasible, e.g. through different quality aspects and proximity to customers. We assume that HRC producers pursue similar strategies as other business sectors with rather standardised products, and strive to differentiate their products further, to become "unique" for their client. This could include additional services and reliability guarantees regarding quality and in-time delivery. Regarding markets and prices, we find regional markets and prices e.g. in North America, Asia, EU, whereas in the EU the prices were the lowest, at least in the period 05/2019 to 02/2020. There are large crude steel producers that act at the global market, but export shares of Germany and the EU are low in relation to their production. So the main market of hot rolled coil for European and German producers is within the EU. Import shares in relation to demand for HRC in Germany range around 12%.Given these market characteristics, the market is rather competitive and individual pricing or premiums depend on the special position and integration of hot rolled coil manufacturers in the value chain.

At the demand side, hot rolled coil manufacturers have to deal with dominating final B2B customers from the automotive industry, in particular for the vehicle body[24]. Consequently, they have

[22] Note: impacts of CO_2 depend on the technology mix and price level. An impact modelling of the ambitious CO_2 targets of the EU (CO_2 price around 100 Euro/t, in 2025, Pietzcker et al. 2021) assesses an increase by 7% of electricity prices compared to the reference.

[23] Note: Impact of CO_2 prices on electricity price depends on the technology mix of electricity generation, on the level of CO_2 price and the fluctuation of the market price. An assessment of ETS impacts on the power stock price reports a 1% change in ETS entails a change in prices of 0.075% (Garcia et al. 2021).

[24] As mentioned in UBA (2024), around 70% of steel used for the production of vehicles is HRC and around 77% of this is used for the manufacturing of the vehicle body (i.e. 54% is HRC of the vehicle body). While HRC is also used for other components, the value chain structure is less transparent due to e.g. steel service centres (see Table 7).

integrated a part of the value chain of hot rolled coil production, both in the EU and Germany. Thus, hot rolled coil producers face a demand side with a few market dominating firms, and vertical integration, both enforcing the competitive situation of hot rolled coil producers. However, existing positive experiences regarding supply flexibility, quality or product adjustment, proximity to customer and trustworthy relationships between suppliers and customers might strengthen the position of HRC suppliers and might offer some scope for cost pass-through at individual levels. Available information on the cost structure and actually obtained market prices are very limited, such that it remains unclear what the margins are (comparable to earnings before taxes (EBT) at the company level). Under the condition that passing-through of higher CO_2 cost is difficult, increasing costs are likely to result in a negative margin. In the case of very small margins, any additional burden drains a company's profit. Regarding the price sensitivity of demand, the assumption of a permanent and clear link between demand and domestic or global HRC prices cannot be supported by our available price and import data, as both demand and prices are driven by many other, external factors such as economic cycles and global actors. The passing on of additional costs caused by regional price changes depends also on the contractual relationship between supplier and customer and the degree of competition in the market. Thus, under individual relationships and contracts, additional costs could be passed through between zero and 100 percent. Under a competitive market situation, the potential passing on of prices is very low.

Illustration of cases

The findings do not allow a clear statement regarding the potential of passing through higher costs. However, it reveals a heterogeneity of potential competitive situations. Therefore, we use the four "competition" cases for HRC (BOF) to illustrate potential effects of a CO_2 price of €100/t on the HRC manufactures. Further, we assume a full factoring in of opportunity costs for all freely allocated CO_2 allowances for the HRC. As CO_2 price we assume €25/t CO_2 and €8/t CO_2 in 2019 and 2015, respectively.

Another option for a price index is the price of CO_2 emission allowances in the EU. We assume a full accounting of CO_2 cost increases, i.e. the cost increase due to CO_2 is fully included in the contract price and augments the contract price by the same magnitude. This assumption reflects a strong and stable business relationship between supplier and customer. In contrast, less strong business relations might allow to include only a share of the CO_2 cost increase. The cost share of the cumulated direct and indirect CO_2 emissions of hot rolled coils[25] amounts to about 10% of the total product price of HRC in 2019 when using €25/t$CO_{2\ eq.}$ or to about 37% under a CO_2 price of €100/t CO_{2eq} (based on CO_2 emission factors per product unit - 2.3 $CO_{2\ eq.}$ t/kg product, cumulated (section 2.3) - and CO_2 costs to total product price). We include all direct and indirect CO_2 emissions since forming of HRC is a consecutive step in the steel production process for the use in the automotive industry.

These various pass-through potentials are depicted in Figure 26, where the horizontal line represents the unit cost level:

The first bar (case 1) on the left displays the hypothetical production costs (cost shares see UBA (2024)) of one unit HRC based on a CO_2 price of 100€/tCO_2 eq. encompassing all direct and indirect CO_2 emissions (see UBA (2024)). Full accountancy of opportunity costs of free CO_2 allocation is assumed. These costs then also represent the total price in an integrated production. Here, the final seller (B2C) - in our case the automotive industry - faces the challenge to pass-through all CO_2 based costs to the final consumer. (If, instead, the integrated firm was a supplier of components to

[25] Note: €25/t CO_2 in 2019, https://www.ecb.europa.eu/pub/economic-bulletin/focus/2021/html/ecb.ebbox202106_05~ef8ce0bc70.en.html; CO_2 intensity of BOF-based hot rolled coil in UBA (2024).

the automotive industry (i.e., B2B), the challenge was, obviously, to pass on the costs to the automotive firm).

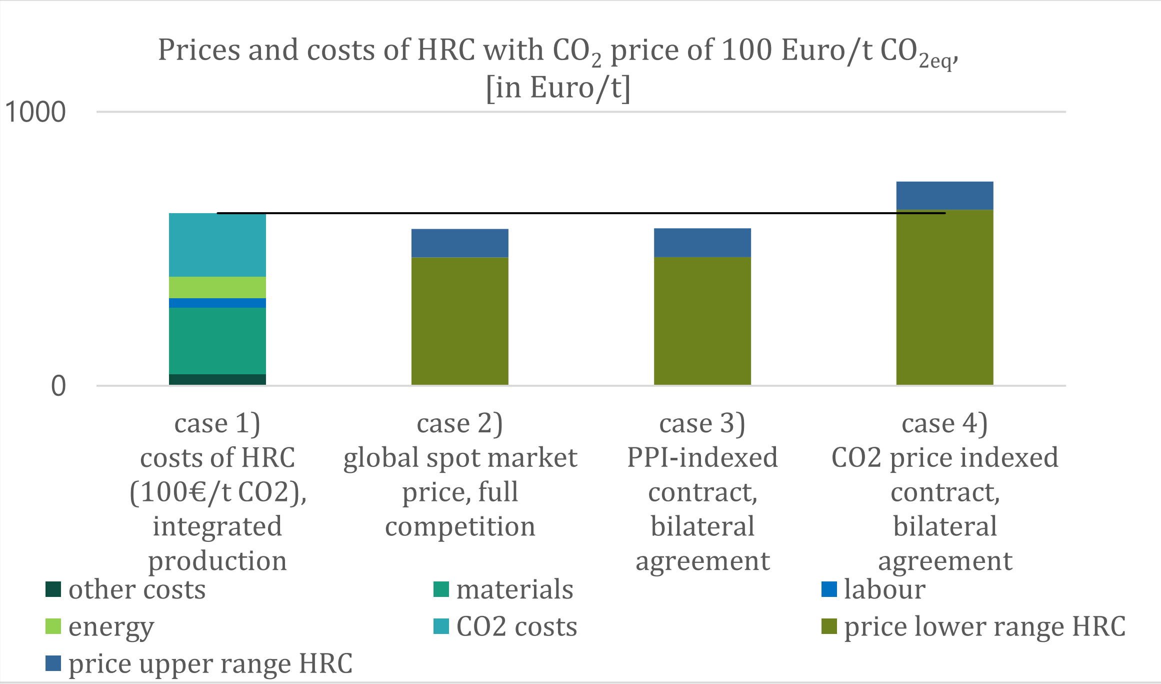
Further, the second bar (case 2) from the left depicts the average of the global spot market prices for HRC (-10% and +10% as lower and upper bound of average global market price 02/2020, see Table 6). It represents the price situation in a global market under full competition and accounts for price volatilities.

The two bars on the right side depict the situation under special relationships and bilateral contracts, in which the global market price of HRC is assumed to be indexed to the national or European producer price index (case 3). Alternatively, the product price is indexed to the CO_2 price of a market (case 4), e.g. EU allowances market (here: €25/tCO_2). We illustrate the impact of the index for a CO_2 price of €100/t CO_2 for both examples - the PPI and CO_2 price index. In the first case the price increases by 0.4% (see paragraph above), in the latter case, the CO_2 cost component of HRC strongly increases, as the CO_2 price is assumed to rise from €25/t CO_2 to €100/t CO_2 (an increase of more than 300%). This leads to a strong increase of the HRC price (lower and upper range), since it is linked to the CO_2 cost component in our example. Again, we assume a price volatility of +/- 10% around the global market price in 02/2020, Table 6.

Based on these assumptions (and the price ranges), this illustration underpins that

1) under full competition (case 2), about one third of the CO_2 price (illustrated in case 1) could not be covered by the market price (global spot market price),
2) under a PPI-indexation (case 3), a bit less than one third of the CO_2 costs (illustrated in case 1)could not be covered (based on the upper price range).
3) under CO_2 price-indexation (case 4), the higher CO_2 costs are added to the lower price range. They could be fully covered. However, we assumed a CO_2 price increase of 300% leading to a HRC price increase of more than 30% of the global spot market price, which is currently beyond the feasible scope.

Figure 26: Potential price pass-through of hot rolled coils (BOF)[26]



Source: own assessment, data displayed in Table 11, data based on Medarac et al. 2020, ECB 2021

4.2 Polyethylene/polypropylene

General findings

The PE/PP pellets production itself is characterised by a low direct energy intensity, while at the upstream production of ethylene and propylene the energy, and hence, the CO_2 intensity is high. Further, primary plastics is a very standardised group, for which global prices exist, while the processed plastic products is a very large and heterogeneous product group, with a large variety of products adjusted to the specific needs of the client. Some large PE and PP pellet supplier have a partly integrated up- and downstream production, for example they integrate the ethylene/propylene and PE/PP production. We focus on the pass-through potential of CO_2 costs at the PE/PP market where PE and PP pellet suppliers meet PE and PP pellet demanders, which further process the pellets in plastics products. In some special cases, even the final plastics production is integrated for example into automotive producers. Under such conditions, the additional costs can be passed through to the final product level of the integrated value chain.

However, most of the customers of PE and PP pellet producers are SMEs that further process the PE and PP pellets into plastics products. These SMEs might purchase PE or PP pellets at the international market as soon as product price plus any other additional costs e.g. transportation costs are lower than domestically produced pellets. A spot and forward contract market exists, but

[26] Note: Prices are from 2017-2021, cost shares are from 2019: free allocation of CO_2 certificates are included as opportunity costs and hence, passed on to the customers as far as market conditions permit. As the free allocation amounts to about 90% of the depicted CO_2 costs, its contribution to total costs is considerable. In reality, the full treatment as opportunity costs is complicated by the fact that in the EU-ETs from 2021 onwards, the free allocation is applied in a dynamic way. De- or increases in production by more than 15% compared to the outset values result in a proportional de- or increase of freely allocated allowances (see ETS Directive 2003/87/EG. The indexing is calculated as follows: the CO_2 costs based on the emitted CO_2 per tonne of produced product and on the CO_2 price of a base year /here: 25 euros/t of CO_2) are deducted from the current market price and the recent CO_2 costs (here 100 euros/t of CO_2) per tonne of produced product are added to the global market price. This is just an example and any other type of indexing is possible.

in addition there are also "shadow prices", in the form of internal transfer prices, that apply in case of integrated production. However, no data is available on the share of spot market, contract market and integrated production volume, respectively.

While spot market prices allow for an immediate adjustment to changing environments, contract prices are less flexible, unless they are indexed to price developments (price indices). The data also shows that changes in prices entail slightly larger changes in import volumes in relative terms, suggesting that increasing prices might lead to a stronger decline in demand.

Illustration of cases

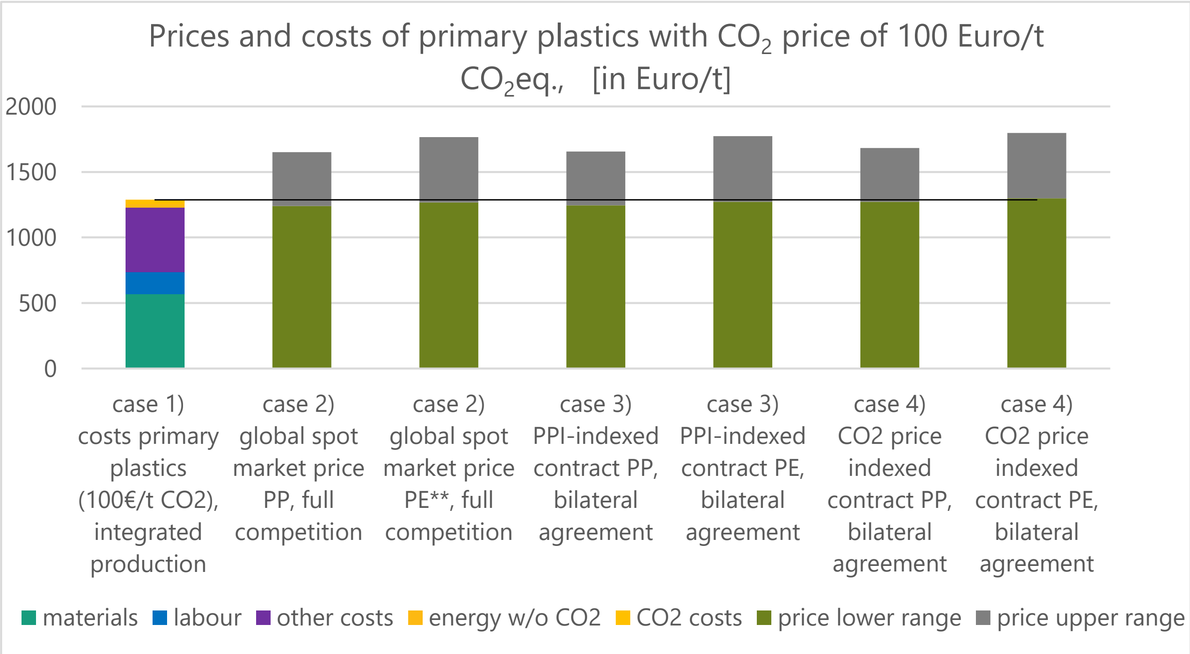
Given the outline and analysis in section 3.2, we conclude that a general derivation of the potential pass-through of CO_2 costs is not feasible as it depends on the specific situation of a company and the respective market. Therefore, and analogously to hot rolled coils (see section 4.1) we distinguish four cases for the PE and PP pellet market. However, in contrast to section 3.1, the upper and lower price range refers to the lowest and highest value of each source as depicted in Figure 27) (see also UBA (2024)): 1) case 1 integration: production costs that are fully passed through within the integrated production to the company - in our case the automotive industry - to the final consumer; 2) case 2 global spot market with full competition: exposure to a global market under full competition at which each supplier is a price taker; 3) case 3 indexing of the total product price with the producer price index (PPI); 4) case 4 indexing the CO_2 cost component to the CO_2 price (EU ETS)CO_2.

These cases are outlined in Figure 27. The horizontal line represents the unit cost level. On the left, the first bar displays the hypothetical production costs of one unit of primary plastics (case 1) based on a CO_2 price of 100€/tCO_2eq., including all indirect and direct emissions. The final seller (B2C) faces the challenge to pass-through all CO_2 based costs to the final customer, in our case to the customer of the automotive industry. The next two bars from the left show the average spot market prices for PP and PE (case 2). They represent the situation at a global market under full competition where no pass-through of additional costs is feasible. They show the upper and lower price range over the considered time period. The next bars depict the situation under a contract for PE that is assumed to be indexed to the producer price index (case 3), or the CO_2 price (case 4). Both represent situations, under which a part of the additional costs could be passed on[27]. Case 1 represents not only an integrated production but also the reference case as it shows the production costs (unit costs). The unit costs of PE and PP products cannot be displayed separately since cost shares are only available for NACE 20.16 and not for sub-groups (see UBA (2024)). Prices and costs refer to 2015. The findings are:

1) Since unit costs depend to a large degree on volatile input prices of ethylene and propylene, there is a range of uncertainty, i.e. in case of a unit cost around €1,500/t primary plastics costs could only be covered by an upper price range.
2) Under the lower price range, CO_2 costs are not covered, neither in case 2 nor in cases 3 and 4.
3) Under the upper price range, CO_2 costs are completely covered and margins could be achieved.

[27] For further explanations, see section 4.1 (hot rolled coils) for the derivation of the assumed pass-through of additional costs.

Figure 27: Potential price pass-through of primary plastics[28]



Source: own assessment, based on data displayed in UBA (2024), ECB 2021 and Table 19.

[28] Note: prices cover the period from 2017 to 2021, cost shares are from 2015 for NACE 20.16, individual data for PE and PP are not available (Eurostat 2021); ** polyethylene HD. The indexing is calculated as follows: the CO_2 costs based on the emitted CO_2 per tonne of produced product and on the CO_2 price of a base year /here: 10 euros/t of CO_2) are deducted from the current market price and the recent CO_2 costs (here 100 euros/t of CO_2) per tonne of produced product are added to the global market price. This is just an example and any other type of indexing is possible.

5 Conclusions

The feasibility of passing-through costs depends on the ability of a company to set prices. In a market with strong competition, price setting is limited, and each individual supplier is rather a price taker. In case suppliers face significantly higher CO_2 prices than the majority of their competitors in the market, we cannot assume that passing-through of costs is feasible. However, even in a very competitive market, a small scope for passing-through of prices exists, namely in the framework of bilateral contracts and product differentiation through indexing of the price or price components. In the negotiation process of the contract, some suppliers might be able to include a pass-on clause for additional costs, for instance, because they have a long-standing customer relationship, and provided high quality and delivery in time. Since indexed prices are normally linked to certain price components or indices, like the PPI, they are unlikely to completely cover all cost increases. Overall, it becomes clear, that a domestic, unilateral pricing of CO_2 challenges the price competitiveness of the domestic carbon-intensive industry.

Under an efficient design of the CBAM, importers of carbon intensive products should face similar CO_2 costs as domestic producers within the EU. Thus, given that there is full transparency and competition in the market, a domestic market price is formed for all suppliers within the EU that accounts for potentially high CO_2 costs, or costs for mitigating CO_2 emissions. Such a situation is comparable with case 4 in sections 4.1 and 4.2. However, on the global market (EU exports), the impact of the CBAM on global prices depends on whether global producers pay for CO_2 emissions or not. They could pay through a) transformation of their whole production into a low-carbon production, or b) a tax, fee or price for CO_2 emissions at their domestic production site. If all players pay for their CO_2 emissions, the global market remains fully competitive, while these additional CO_2 costs are then fully included in the price by all producers (ideally as depicted in case 4 in sections 4.1 and 42). If global producers do not face and integrate CO_2 mitigation costs (and there are large global players), European producers will face a cost disadvantage (their costs are already not covered in the domestic market, where prices below the global level point to a high competition) when exporting to the global market (and without CBAM also at the import market) as depicted in case 2 in sections 4.1 and 4.2.[29]

To highlight the CO_2 cost-sensitivity of the industry, the CO_2 cost-coverage potential is displayed in Figure 28. It depicts the difference between the specific product price and the unit costs of HRC (BOF) without CO_2 costs as a share of the CO_2 costs of HRC (100€/t CO_2).[30] Therefore, it shows to what extent the product price could cover the specific CO_2 costs of HRC. This is illustrated for the cases 2-4, and for primary plastics as well:

- A negative value indicates that the market price is lower than the specific production costs of HRC or PE (PP) and neither CO_2 nor other input costs are covered.
- A positive value between 0 and 1 shows the share of the costs covered by the respective market price.

[29] HRC (2019): Based on the total production of HRC (38.7 Mt), the imports (9.3 Mt) and the exports (4.1 Mt) around 43.9 Mt HRC are available on the EU market (Eurostat 2020b; WSA 2023). Around 11% of HRC is exported. Note: this includes trade flows within the EU as no statistics reports the extra-EU trade separately on product level.

All finished steel products (2019): Total production (143.6 Mt), imports (154.1) and exports (133.8 Mt) lead to a domestic market volume of 163.9 Mt. Around 93% of the total production is exported in total. Roughly 26 Mt or 18% are exported to countries outside the EU (Eurostat 2020b; WSA 2023).

Comparison (2019): Around 27% of steel products, 6% of the imports and 3% of the exports are HRC (Eurostat 2020b; WSA 2023). Note: this includes trade flows within the EU as no statistics reports the extra-EU trade separately on product level.

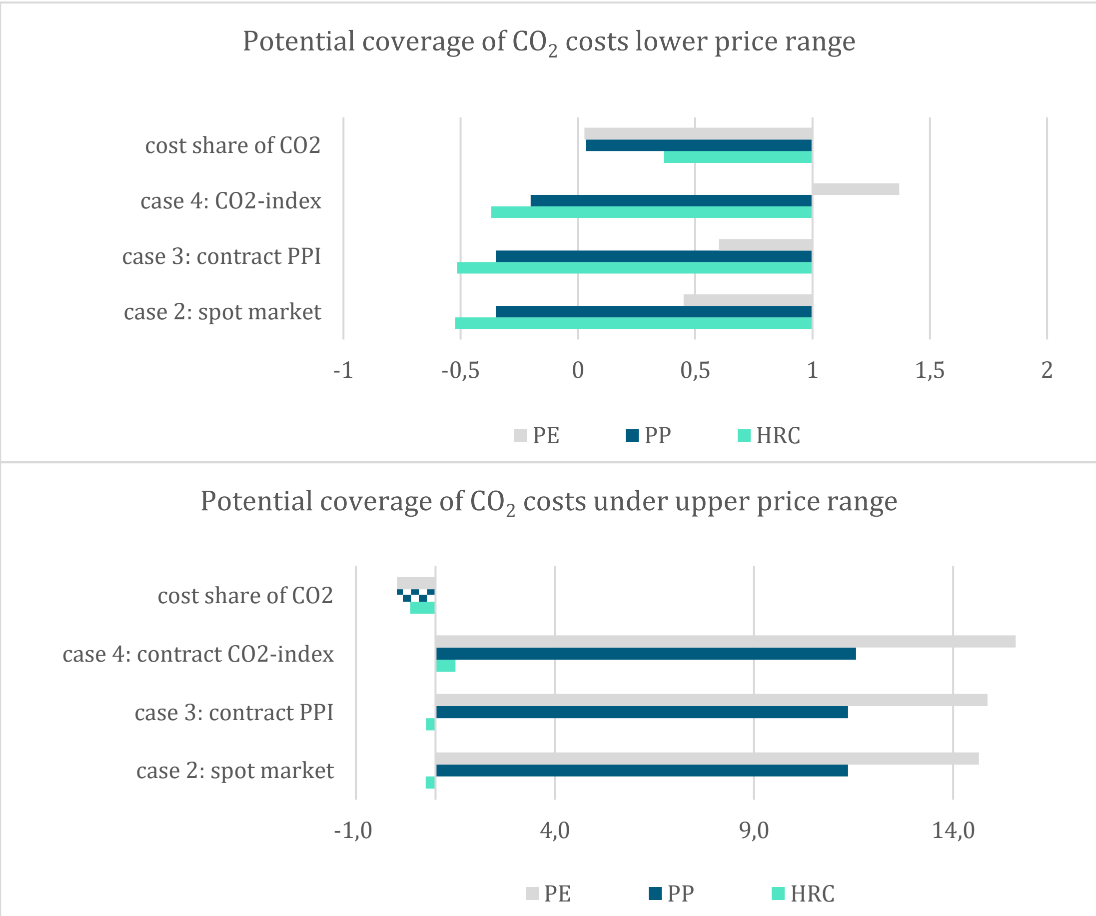
[30] CO_2 cost coverage $_{HRC}$ = (product price $_{HRC}$ - (unit costs $_{HRC}$ - CO_2 costs $_{HRC}$)) / CO_2 costs $_{HRC}$

- A value of 1 reveals full coverage of the specific CO_2 costs.
- A value of > 1 signals a profit margin (all costs, including CO_2 are covered).

The findings show that in the primary plastics industry the coverage of specific CO_2 is not given in the lower price range for PP products, but ranges between 40% and 140% for PE. In the upper price range, it is more than fully covered for both products, while in the HRC-producing sector, a full coverage is only given for case 4.

Overall, under high price fluctuations and a small CO_2 cost share, the coverage of specific CO_2 costs is rather sensitive to product prices and might take extreme values as in the case of primary plastics. This illustration implies that in situations with low market prices and unchanged unit costs of production, primary plastics producers are likely not be able to cover all input costs, while in times with high market prices (upper price range case 2, 3 and 4) their coverage is even beyond a full CO_2 cost coverage.

Figure 28: Potential cost coverage of CO_2 costs – upper and lower price range.



Source: own assessment

CO_2 Non-integration of primary plastics or HRC along the value chain

If HRC or primary plastics are not integrated in the upstream value chain of a BEV producer, cost increases are (partly) born by the suppliers of HRC and primary plastics. In a competitive market with price takers (spot market), the coverage of CO_2 costs is lowest. The total costs share of CO_2 in PE or PP pellets amount to about 3%, that of HRC to about 37%[31]. Due to this low cost share of CO_2

[31] 100 Euro/t CO_2eq., emission factors see UBA (2024), prices see Table 6 and Table 13.

in PE or PP pellets, the degree of CO_2 cost coverage is extremely sensitive to market price changes and shows a wide range of values. In contrast, the cost share of CO_2 is high for HRC, and the variations are by far lower than for primary plastics. Regarding the CO_2 cost coverage, only in case 4, the CO_2 costs can be fully covered. For the other cases 2 and 3, CO_2 costs are only covered between 30% and 80%. These results are illustrated in Figure 28. It is important to note that these values should be seen as indicative values pointing out a direction but not the absolute and exact magnitude of the pass-through. They are based on certain assumptions on costs and prices and do not fully reflect the whole variety and heterogeneity of the various supplier-customer relationships.

Integration of primary plastics and HRC in the downstream value chain

In case HRC and PE and PP production is fully integrated in the BEV value chain, we assume a complete pass-through of CO_2 costs to the final product, the BEV. Total costs of all CO_2 (€100/t CO_2eq) amount to less than 2% of the BEV costs[32]. The CO_2 costs of PE, PP and HRC are around 0.1% and 1%, respectively (see section 4, Figure 25). A key question is how competitive are European automotive producers, how integrated is the HRC production for BEV, and how competitive is the market? Are the automotive producers able to pass through this small cost share? Since the analysis of the automotive sector and BEV market are beyond the scope of this study, we cannot provide any conclusions on this question. Currently, global BEV producers are, however, very competitive and are gaining BEV market shares in Germany. On the other side, demand for BEV is rising in Germany. This is partly driven by several factors such as financial supports from the German government, rising awareness regarding climate change, or the energy crisis as a result of the Russia-Ukraine war. Therefore, we assume that the CO_2 costs could be rolled over as long as demand for BEVs grows.

[32] with increasing price of BEVs, this share decreases

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List of Abbreviations

Abbreviation	Description
ABS	Acrylnitril-Butadien-Styrol-Copolymer
AP	Arbeitspaket
BEV	Battery electric vehicle
BF	Blast furnace
BOF	Basic oxygen furnace
C.II/ C.III	Complexity I/ complexity III
C_2F_6	Hexafluoroethane
$CaCO_3$	Calcium carbonate
CAEF	The European Foundry Association
CAPEX	Capital expenditures
CDU	Crude distillation units
CEM (I, II, III, V)	Cement types based on DIN EN 197-1
CF_4	Carbon tetrafluoride
CH_4	Methane
CHP	Combined heat and power
CO_2	Carbon dioxide
CO_2eq	Carbon dioxide emission equivalent
COP	Conference of the Parties
CRF	Cold rolled flat
CSV	Comma-separated values
CWT	Complexity weighted tonne
BEV	Battery electric vehicle
EAF	Electric arc furnace
EEA	European Environment Agency
EFTA	European Free Trade Association
el index	Electricity price index
EU	European Union
EU Alumin.	European Aluminium
EU ETS	EU Emissions Trading Scheme
EU28	Member states of the European Union (2015)
EUA	European Union Allowance
EUSTAT	European Statistics
EUTL	EU Transaction Log
FCCU	Fluid catalytic cracking unit
FED	Final energy demand
F-gases	Fluorinated greenhouse gases
FTIP	Federal Transport Infrastructure Plan

Abbreviation	Description
GDA	Gestamverband der Aluminiumindustrie
GGBS	Ground-granulated blast furnace slag
GHG	Greenhouse gas
GHG	Greenhouse gas
GJ	Gigajoule
H_2	Hydrogen
HCU	Hydrocracker
HDPE	High density polyethylene
HE	High efficiency
HGV	Heavy goods vehicle
HRC	Hot rolled coil
HRWS	Hot rolled wide strip
HS	Harmonised system
HVC	High value chemicals
ICAO	International Civil Aviation Organization
ICEV	Internal combustion engine vehicle
IMO	International Maritime Organization
ISIC	International standard industrial classification
Kg	Kilograms
KSBV	UBA study Klimaschutzbeitrag des Verkehrs bis 2050 [UBA, 2016a]
Kt	Kilotons
kWh	Kilowatt hours
LCA	Life cycle analysis
LDPE	Low density polyethylene
LE	Low efficiency
LHV	Lower heating value
LLDPW	Linear low density polyethylene
LPG	Liquefied petroleum gas
MFA	Material flow analysis
MFCA	Material Flow Cost Accounting
MJ	Megajoule
Mm	Millimetres
Mt	Megatonnes
MWh	Megawatt hours
N_2O	Nitrous oxide
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne
NDC	Nationally Determined Contributions (in Paris-Agreement)
NEDC	New European Driving Cycle
OECD	Organisation for Economic Co-operation and Development

Abbreviation	Description
OPEX	Operational expenditures
PA	Polyamid
PC	Polycarbonate
PDF	Portable document format
PE	Polyethylene
PJ	Petajoule (energy measuring unit)
PKW	Personenkraftwagen
PP	Polypropylene
PPI	Producer price index
PtG	Power-to-Gas (any power-based gaseous fuels)
PtL	Power-to-Liquid (any power-based liquid fuels)
PU	Polyurethane
PVC	Polyvinylchloride
RCA	Revealed Comparative Advantage
RDE	Real Driving Emissions
RES	Renewable energy sources
REV	Revision
SEC	Specific Energy Consumption
SGHG	Specific greenhouse gas emissions
SITC	Standard international trade classification
T	Tonnes
THG	Treibhausgasemissionen
TJ	Terrajoule
TWh	Terawatt hours (measuring units for energy)
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VCI	Verband der Chemischen Industrie
VDeH	Verein Deutscher Eisenhüttenleute
VDU	Vacuum distillation unit
VDZ	Verein Deutscher Zementwerke e.V.
VET	Verified emissions tables
WLTP	Worldwide Harmonized Light-Duty Vehicles Test Procedure
WMS	World Metal Statistics
WSA	World Steel Association
WV Stahl	Wirtschaftsvereinigung Stahl

A.1 Energy balance of battery electric vehicle

Table 20: Energy demand by productive phase and energy source for battery electric vehicle

Material/ Product	BEV Weight [kg]		**Energy demand by process [MJ]**	**Energy demand by source [MJ]**						**Energy demand by process [MJ]**	**Energy demand by source [MJ]**			
		Total energy demand [MJ]	Raw material	**Electricity**	**Coal**	**Coke**	**Natural gas**	**Oil**	**Other gases**	**Part production**	**Electricity**	**Coal**	**Natural gas**	Oil
PA/Nylon	18.15	1,190	23	13			10			1,167	1,124		44	
PP	75.67	1,718	1,491	151			91	1,249		227	227			
PE	20.25	527	385	55				330		142	142			
PU	43.18	2,754	2,754	907			1,209	639						
PC	3.11	149	140	22			118			9	9			
PVC	13.11	538	511	39			472			26	26			
ABS	37.25	2,049	1,937	149	74		1,713			112	112			
Rubber	23.26	1,106	929	9			460	460		177	55		122	
Copper wire	16.13	418	370	122	61		161	26		48	32	0		16
Steel	**528.31**	0												

Hot rolled coils (preassembly)	316.92	6,634	6,634	444	1,317	3,036	755	36	1,047					
Hot rolled coils	54.03	1,442	1,131	76	224	518	129	6	178	311	65	246		
Hot rolled bars machining	134.89	615	530	366	70	70	24			85	85	0		
Hot rolled bars forging	22.48	1,027	88	61	12	12	4			939	31	908		
Aluminium	**302.64**	0	0											
Stamping (preassembly)	63.80	132	132	71			58	2						
Casting	183.73	2,146	2,146	860			1,235	51						
Extrusions	55.12	242	242	18			215	9						
Flat glass	32.40	705	144	0	137		0	7		561	92	0	469	0
Zinc	15.81	270	270	250			21							
Copper	45.57	1,458	1,458		456		866	137						
Graphite	34.41	2,890	2,890		1,445		344	1,101						
LiMnO	35.45	1,312	1,312		213		886	213						
Ethylene carbonate	28.29	255	255				170	85						