

Report prepared for Committee on Climate Change

Competitiveness impacts of carbon policies on UK energy-intensive industrial sectors to 2030



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Executive Summary

The purpose of this project was to support the Committee on Climate Change (CCC) in its ongoing assessment of the impact of low carbon policies on energy prices and bills, and the competitiveness implications of climate change policies and energy prices on the UK manufacturing sectors.

To do this, the project carried out

- An analysis of electricity prices faced by manufacturing sectors in the UK against prices faced by manufacturing sectors in other key countries. This analysis was extended to develop projections of electricity prices in the UK and competitor countries out to 2020 and 2030.
- An assessment of EU ETS free allowance allocation for on UK firms to date; and an assessment of the likely EU ETS free allowance allocation out to 2030 based on current proposals (and assuming the UK remains within the EU ETS).
- Analyses of trends and developments in three industries (aluminium, cement, steel) that have contracted and are illustrative of the trends and pressures faced by electro-intensive industries, to understand the cause of the contraction and the role of climate change policies in the contraction.

Key findings

UK sectors face high industrial electricity prices

Our analysis of industrial electricity prices in the UK and other countries indicates that electro-intensive industries in the UK face higher electricity prices than most of the international competition despite substantial relief in the form of exemptions and compensation schemes to offset policy costs.

Wholesale and network costs explain the price differential

In some cases, UK relief is lower than elsewhere, but the main factors that explain the price differential are higher wholesale and network costs in the UK. Wholesale electricity prices in the UK are typically higher than those faced by key trading partners, while network costs are a larger part of the final electricity price paid by industry in the UK, than among trading countries¹. Crucially, larger firms in some of the key competing countries benefit from sizeable discounts (exemptions) in network and transmission costs.

The gap in electricity prices is expected to persist and, in some cases, widen

Based on our own projections, we expect the electricity price gap to persist until 2030. We also expect the gap between European industries and their US and Chinese competitors to widen, due to an expected increase in the EU ETS price. In the sectors that do not face policy cost exemptions, the UK price increase is more pronounced than in most other countries.

¹ Based on Eurostat (2016) estimates, see Appendix B for more information on the limitations of this data.

Historical over-allocation of EU ETS permits to all sectors

An analysis of the under- or over-allocation of EU ETS permits and the net value of this allocation to a selection of UK industries finds the same broad pattern of over-allocation historically for all sectors. This was driven largely by over-allocation in Phase II, when output and emissions were strongly affected by the global economic crisis. The value of the over-allocation was relatively low, however, because of the low carbon price at the time.

A future of under-allocation of EU ETS permits, with varying impacts

Looking to the future, all industrial sectors can expect to receive allowances lower than recent verified emissions in Phase IV of the EU ETS. However, the relative size and value of the allocation deficit changes markedly depending on the sector, the proposed method of allocating permits and the carbon price projection.

The tiering approaches are better suited to sectors at high risk of carbon leakage

Broadly speaking, the proposed tiering approaches are more effective in supporting the sectors most at risk of carbon leakage than the proposed binary approach. Of the tiering approaches, the UK/FR Phase IV proposal seems better at targeting sectors at high risk of carbon leakage, while the EC IA proposal is more generous to sectors at middle or low risk at the expense of the higher risk sectors.

Assuming full carry-over of unused allowances to subsequent years (banking), we estimate that both the level of potential free allowances and how long the cumulative over-allocation would last vary across sectors. Depending on the scenario, the historical over-allocation could have run out in 2021 or 2022 in some industries, while in others the historical over-allocation could cover projected deficit in all Phase IV scenarios. In others, free allowances could have run out in 2016, with a deficit relative to 2008-2030 emissions by the end of Phase III one projected outcome.

Low carbon policies and delays in providing compensation have impacted on energy-intensive industries...

The impact of low carbon policies on energy prices and their role in the decline of the three case study sectors (aluminium, cement, steel) has been negative but relatively small. Under the EU ETS, each sector benefited from the over-allocation of free emissions allowances. For industry as a whole, this helped to offset the indirect costs associated with increased electricity costs. Beyond the EU ETS, UK-specific climate change policy also contributed to rising electricity prices. The following policies are given exemptions under the EII:

- Renewables Obligation, introduced in 2002
- Feed in Tariffs (FiTs), introduced in 2008
- EU ETS, introduced in 2005
- Carbon Price Support (CPS), introduced in 2013
- The Climate Change Levy (CCL), introduced in 2001
- Contracts for Difference (CFD), introduced in 2014

But the UK government was slow to compensate energy intensive industry for these climate change policies. Compensation and exemptions for many of these policies were introduced through the Energy Intensive Industries (EII) package. The EII package was introduced by the government in 2011 and to be implemented in 2013, but most of the package was not implemented until 2016.

...but other market and industry factors have been more important at driving the contraction of industries

Our analysis for the aluminium, cement and steel sectors case studies reveals that the steel and aluminium sectors have been in long-term decline since the late-1990s, while cement production was stable over 1995-2007.

A major driver of the contractions in the three sectors under study was a sharp fall in demand during the 2008-09 recession, driven by contractions in key customer sectors such as motor vehicles, construction and packaging, as household spending and investment fell sharply. Very quickly, production in each sector fell by 20-30% and since then it has remained flat or fallen further.

The key reasons for these declines and the struggle to recover are:

- for steel and aluminium, weak market conditions, particularly at the turn of the century, characterised at various times by weak demand and low global prices. This was compounded by a strong pound, which undermined the competitiveness of exports and facilitated an increase in competition from imports.
- on labour-based measures (labour productivity and unit labour costs), the UK sectors were typically middling or slightly inferior over the historical period, but have improved in relation to their French and German counterparts, or at worst moved in line, since 2008. However, weak demand in the domestic and EU markets and strong import competition mean this has not come through in production and trade.
- unit energy costs were typically higher and/or grew faster in the UK prior to 2008. By contrast, producers in France typically enjoyed lower and more stable unit energy costs. This is because over the historical period producers in the UK were more reliant on fossil fuels for their energy needs, both directly and indirectly (electricity), and the prices of fossil fuels (oil, gas, coal) rose sharply between the early 2000s and 2008, roughly four-fold. This knocked on to industrial electricity prices, with average industrial electricity prices practically trebling over the period.
- marked increases in import penetration in each market as domestic producers, for the reasons outlined above, struggled to compete against imports made cheaper by a strong pound. Particularly in steel and aluminium, this appears to have been compounded as the pace of globalisation picked up and the UK industries were restructured away from unprofitable and uncompetitive activities focused on serving primarily the domestic market to more profitable and competitive activities located within a wider supply chain serving the global market. This can be seen in a corresponding increase in the share of domestic output that is exported over the period.
- The overarching consequence of the trends outlined above was declining profitability and increased uncertainty about profit levels. The corollary of this has been weak or falling investment in each of the three UK sectors studied here. This has served to reinforce the contraction in domestic production and the reliance on imports.

1 Introduction

Context To tackle climate change, countries across the world have developed and implemented policies to reduce carbon emissions. The policies put in place have been diverse, ranging in ambition, scope, coverage and design. The costs of these policies are borne unevenly across countries giving rise to concerns about competitiveness. At the focal point of these concerns are energy intensive industries operating in global markets.

As countries introduce increasingly stringent carbon reduction policies, there is a risk that firms relocate production to countries with more lenient carbon reduction policy regimes. The outcome of this would be lower economic output and employment in the country that introduced the stringent carbon reduction policies, with no global environmental benefit as production, and the carbon emissions associated with production, is simply relocated elsewhere in the world. This phenomenon is called “carbon leakage” and could undermine efforts to successfully reduce global carbon emissions.

Policy-makers in the UK and the European Union have put in place a variety of measures that affect energy-intensive industries operating in the UK, ranging from their direct inclusion in the EU ETS to policies that lead to higher electricity costs to support the uptake of renewable energy technologies. Directly offsetting this, electro-intensive industries in the UK also receive compensation, designed to offset the increasing costs of electricity. Equally, industries considered at risk of carbon leakage have been freely allocated 100% of benchmarked emissions and this will continue until at least 2020.

Looking further ahead, the European Commission is currently in the process of determining the policy detail for Phase IV of the EU ETS, such as rules for determining sectors at risk of carbon leakage and the distribution of free allowances. Moreover, following the Paris Agreement, it is no longer clear that support needs to be provided if major trading partners are implementing comparable measures. It is also worth considering what the policy measures might look like following ‘Brexit’.

Project objectives

In that context, the purpose of this project was to support the Committee on Climate Change (CCC) in its ongoing assessment of the impact of low carbon policies on energy prices and bills, and the competitiveness implications of climate change policies and energy prices on the UK manufacturing sectors in the past, today and into the future.

To do this, the project carried out

- An analysis of electricity prices faced by manufacturing sectors in the UK against prices faced by manufacturing sectors in other key countries. This analysis was extended to develop projections of electricity prices in the UK and competitor countries out to 2020 and 2030.

- An assessment of EU ETS free allowance allocation for on UK firms to date; and an assessment of the likely EU ETS free allowance allocation out to 2030 based on current proposals (and assuming the UK remains within the EU ETS).
- Analyses of trends and developments in three industries (aluminium, cement, steel) that have contracted and are illustrative of the trends and pressures faced by energy-intensive industries, to understand the cause of the contraction and the role of climate change policies in the contraction.

Outputs

The key outputs of this study are this project report, accompanying Excel workbooks for the analyses of electricity prices and the impact of the EU ETS, and three standalone case study reports for the aluminium, cement and steel sectors.

This report is structured as follows:

- Chapter two presents the analysis of electricity prices faced by manufacturing sectors in the UK and in other key countries.
- Chapter three presents the assessment of the direct impact of the EU ETS on UK firms to date and into the future
- Chapter four presents the executive summaries from each of the case study sector reports. The full sector reports are provided separately.
- The key findings of chapters two-four are brought together in a concluding synthesis.

2 Industrial electricity prices

2.1 Key messages

The aim of this task was to estimate and compare final electricity prices faced by electro-intensive industries in the UK and in key competing countries in 2016, 2020 and 2030. As well as explaining the reasons behind the choice of selected industries and countries, this chapter explains how the different price components of the electricity price were estimated and presents the key results. The following main findings can be highlighted.

1. Electro-intensive industries in the UK face higher electricity prices than most of the international competition despite the existence of substantial relief in the form of exemptions and compensation schemes to offset policy costs. Some UK industries are paying over £40/MWh more than their direct EU competitors, and the price differential is even greater when comparing to electricity prices in the US. Even with sector-based relief in the UK, electricity prices are generally higher than for competing industries overseas. In some cases, UK relief is lower than elsewhere², but the main factor that explains the price differential is higher wholesale and network costs in the UK.
2. Network costs are a larger part of the final electricity price paid by industry in the UK, than among trading countries³. Crucially, larger firms in some of the key competing countries benefit from sizeable discounts (exemptions) in network and transmission costs. Wholesale electricity prices in the UK are also higher than those faced by key trading partners. This could partly be explained by the relative illiquidity of the UK market⁴.
3. Among the most important trade partners for the UK, only Germany has similar before-relief industrial electricity prices. The UK and Germany both introduced policies to finance the promotion of renewables, which are ultimately paid for in consumer (industrial and domestic) electricity prices. The most energy-intensive German firms can pay a lower price than their British competitors.
4. Having estimated projections of the electricity price, we expect the electricity price gap to persist until 2030. This is due to similar predicted increases in wholesale fuel prices, carbon cost and other policy costs in the UK and competing European countries. In the UK, we assume the largest percentage increase in renewable electricity

² For example, some industrial consumers receive over 85% relief from the EEG Umlage in Germany. Plants consuming 1GWh/year-10GWh/year receive 90% relief, plants consuming over 10GWh/year receive at least 99% relief.

³ Based on Eurostat (2016) estimates, see Appendix B for more information on the limitations of this data.

⁴ Ofgem (2016), 'Wholesale Energy Markets in 2016'. Available online:

https://www.ofgem.gov.uk/system/files/docs/2016/08/wholesale_energy_markets_in_2016.pdf

generation over the projection period (increasing from 15% of total generation in 2016, to 50% of total generation by 2030). We assume that policy costs grow in line with total renewable generation and therefore, in the sectors that do not face policy cost exemptions, the UK price increase is more pronounced than in most other countries. We also expect the gap between European industries and their US and Chinese competitors to widen, due to an expected increase in the EU ETS price.

2.2 Overview of chapter

This chapter describes our methodological approach and the key data sources and assumptions we used in the derivation of the electricity price. We present the core findings from our analysis and assess the robustness of the results, reflecting on key sensitivities that were tested.

This remainder of this chapter is organised as follows:

- Section 2.3 explains our choice of sectors and countries for the analysis
- Section 2.4 and Section 2.5 summarise industry-specific policy cost exemptions that are applied
- Section 2.6 describes our approach to estimating industry electricity prices over the period to 2030
- Section 2.7 presents our results for sectoral electricity prices in the UK
- Section 2.8 presents an international comparison of electricity prices among industrial profiles

2.3 Defining the scope of the task

The first sub-task was to select a group of sectors and countries for the electricity price comparison. This section presents the motivations behind our choice of industrial sectors and comparator countries.

Sector coverage

The focus of the analysis was on electro-intensive industries with high exposure to international competition, as these industries will be most affected by increasing electricity prices due to low-carbon policy in the future. For the UK, policy cost relief is specified at a sectoral level and so we assessed current and expected future electricity prices at this level of detail. For the comparator countries, however, we found that many policy cost exemptions for the most part are defined by a firm's annual electricity consumption or electro-intensity. For simplicity, the assessment of electricity prices in these countries, was based on three industry profiles reflecting varying degrees of electro-intensity.

Electricity and trade-intensity characteristics

The sectors at most risk of production losses from a lack of competitiveness caused by high electricity prices in the UK are those which are: (i) highly electro-intensive and (ii) highly exposed to international competition. To determine which UK industry sectors fall into this group, we used two indicators to measure the level of electro- and trade intensity. The electro-

intensity indicator is the ratio between electricity consumption and gross value added at basic prices. The trade intensity indicator is calculated as the ratio between imports and domestic production and highlights the sectors that are most exposed to international competition. Table 2.1 shows these indicators for the selected list of industries in the UK. Data on domestic production is taken from the ONS Annual Business Survey (2016)⁵, annual electricity consumption data are taken from the Department for Business, Energy and Industrial Strategy (BEIS, 2016)⁶. Imports data comes from the Eurostat COMEXT database⁷.

The industries listed in Table 2.1 were selected for the analysis as they are most electro-intensive and operate in highly competitive markets. The preliminary analysis at the SIC 4-digit level shows that import intensity in 2015 was particularly high for the 'Aluminium production', 'Other porcelain and ceramic products' and 'Paper and paper products' sectors. 'Aluminium production', 'Cement' and 'Industrial gases' are the sectors that rely most heavily on electricity as an input to the production process. The data in Table 2.1 highlight that the sectors we considered are relatively more vulnerable to higher (or increasing) electricity prices.

To reflect that, in some countries, different steel production processes face different electricity prices, a distinction was made between steel manufacturers relying on an Electric Arc Furnace (EAF) and those with a Basic Oxygen Furnace (BOF). The final list of sectors selected for the UK electricity price analysis is the following:

- Steel EAF and Steel BOF
- Paper and paper products
- Industrial gases
- Fertilisers and nitrogen compounds
- Plastic products
- Other porcelain and ceramic products
- Cement
- Glass and glass products

⁵ Office for National Statistics, 2016. *Annual business survey: Great Britain non-financial business economy exporters and importers, 2015 provisional results*. [pdf] London: Office for National Statistics. Available at: <https://www.ons.gov.uk/businessindustryandtrade/business/businessservices/articles/annualbusinesssurvey/greatbritainnonfinancialbusinesseconomyexportersandimporters2015provisionalresults>.

⁶ Department for Business, Energy and Industrial Strategy, 2016. *Energy consumption in the UK*. [pdf] London: Department for Business, Energy and Industrial Strategy. Available at: <https://www.gov.uk/government/statistics/energy-consumption-in-the-uk>.

⁷ The database is available at the following link: <http://epp.eurostat.ec.europa.eu/newxtweb/>.

Table 2.1: List of selected industries by electro and trade-intensity

	SIC 2007 ⁸ Code	2008				2015
		Domestic production (m€)	GVA (m€)	Annual elec. use (GWh)	Electro-intensity (GWh electricity consumption / million € GVA)	Trade-intensity (imports/ domestic production)
Paper and paper products	17	13,555	3,466	8,199	2.4	59.7
Industrial gases	20.11	1,700	845	3,245	3.8	-
Fertilisers and nitrogen compounds	20.15	2,549	475	1,023	2.2	47.0
Plastic products	22.20	22,686	8,403	8,781	1.0	32.6
Other porcelain and ceramic products	23.40	1,035	411	326	0.8	95.2
Cement	23.51	782	335	1,570	4.7	-
Glass and glass products	23.10	4,217	1,457	1,745	1.2	39.6
Aluminium production	24.42	3,048	595	5,757	9.7	169.0
Basic iron and steel	24.10	11,212	2,691	3,850	1.4	51.4
Fabricated metal products	25	43,031	17,859	5,059	0.3	25.0
Sectors considered as a share of total manufacturing sector (%)	-	16.5%	19.5%	33.2%	-	-

Notes: 2008 is the latest year for which annual electricity consumption data at the 4-digit SIC level is available, hence why 2008 data was used to calculate electro-intensity for these sectors. No turnover data is available to calculate trade intensity for 'Cement' and 'Industrial gases'.

Source: CE based on ONS, BEIS and Eurostat data.

⁸ Standard Industrial Classification of economic activities (SIC).

Selecting countries for comparison

- Aluminium production
- Fabricated metal products

The electricity price comparison focuses on the key trading partners for the UK in electro-intensive products. To determine those countries that are the UK's key competitors for these products, we collated bilateral trade data for electro-intensive sectors and assessed import intensity (the share of sectoral imports over sectoral domestic production). The Eurostat COMEXT database provides data at the 4-digit level allowing the identification of the most relevant sources of imports and destinations of exports for the selected sectors. By analysing 2015 data, it was possible to highlight the countries most involved in trade of electro-intensive products and, therefore, competing with UK industries. The data shows that the following countries are the key trade partners for the UK in energy-intensive products:

- Germany
- China
- United States of America (USA)
- France
- Netherlands
- Belgium
- Ireland

The data showing trade intensity for key international competitors is presented in the following tables. Table 2.2 presents, for each sub-sector, the share of total imports from each partner country.

As in the previous case, Table 2.3 shows the share of exports to each country. The importance of each country as a trading partner to the UK varies by the sector considered. Nevertheless, Germany, China, the United States and France are particularly important trading partners for almost all the sectors that we considered. Due to its location and commercial relationships, Ireland is a key destination of UK exports. The remaining two countries, Belgium and the Netherlands, are critical exporters in the 'Industrial gases', 'Fertilisers and nitrogen compounds' and 'Basic iron and steel' industries and play a small role in most of the other sectors. These seven countries represent around 50% of international trade with the UK for the sectors we considered.

Table 2.2 Share of UK imports by sector and by trade partner

	Germany	China	USA	France	Nether-lands	Belgium	Ireland	Share of all UK imports from listed countries
	Share of total UK imports (%)							
Paper and paper products	16.8	7.7	4.2	6.8	6.2	5.6	-	47.3%
Industrial gases	25.9	-	22.4	14.4	11.1	7.0	3.5	84.3%
Fertilisers and nitrogen compounds	12.1	-	-	3.8	18.7	8.5	3.5	46.6%
Plastic products	19.0	17.8	8.1	7.3	5.2	4.9	3.1	65.4%
Other porcelain and ceramic products	26.7	29.9	2.7	2.2	-	-	-	61.5%
Cement	1.2	2.1	0.6	31.8	-	-	29.2	64.9%
Glass and glass products	14.8	23.0	7.6	11.1	3.3	4.9	2.5	67.2%
Aluminium production	34.3	6.1	6.2	8.3	3.0	-	-	57.9%
Basic iron and steel	15.0	10.0	-	7.0	11.0	11.0	-	54.0%
Fabricated metal products	16.0	22.4	6.2	5.3	4.3	2.8	-	57.0%

Source: CE based on Eurostat data.

Table 2.3 Share of UK exports by sector and by trade partner

	Germany	China	USA	France	Nether-lands	Belgium	Ireland	Share of all UK exports from listed countries
	Share of total UK exports (%)							
Paper and paper products	11.0	-	7.1	9.3	5.1	3.1	22.8	58.4%
Industrial gases	5.3	-	3.6	5.9	-	-	21.6	36.4%
Fertilisers and nitrogen compounds	20.7	-	-	10.6	6.0	2.8	11.2	51.3%
Plastic products	12.6	-	9.7	9.3	6.6	3.6	10.1	51.9%
Other porcelain and ceramic products	6.9	-	15.1	4.7	3.3	-	11.3	41.3%
Cement	21.7	-	-	11.0	-	-	14.8	47.5%
Glass and glass products	11.6	-	8.4	8.3	3.5	5.7	15.8	53.3%
Aluminium production	36.9	-	4.4	12.1	8.1	2.7	3.4	67.6%
Basic iron and steel	11.4	-	12.1	9.3	5.6	-	5.5	43.9%
Fabricated metal products	7.5	-	8.4	5.6	4.4	-	7.0	32.9%

Source: CE based on Eurostat data.

Electricity prices in the US

There is considerable variation among US states in policy costs, taxes and industrial electricity prices and, for this analysis, Texas was selected as a proxy for the US. The choice of Texas as a representative state is based on three key factors:

- Texas has a particularly high concentration of energy-intensive firms
- the electricity generation mix in Texas is similar to the US as a whole
- the average industrial electricity price in Texas is 25% lower than the US average, and so is an important state from the competitiveness perspective

Gross Value Added (GVA) from energy-intensive firms in Texas is the largest of all US States and represents approximately 12% of the US total energy-intensive industries' GVA. By considering a state with one of the most

competitive electricity prices in the US, we obtain a relevant indicator of the threat to UK competitiveness.

2.4 Industry-specific policy cost relief

To support the competitiveness of domestic industry, many countries have introduced tax exemptions and compensation schemes for electro-intensive sectors experiencing rising electricity prices and international competition. As taxes and levies can represent a significant portion of the final electricity price faced by industrial customers, these measures can provide an effective relief to electro-intensive firms. The UK issued sector-specific schemes to reduce the policy costs charged to firms through the retail electricity price. Most of these schemes apply to environmental taxes/levies aimed at promoting energy efficiency or the adoption of renewable sources of energy. The manufacturing industries that benefit from these reductions are among the most electro-intensive and most exposed to international competition. Most (but not all) of the industry sectors listed in Table 2.1 do meet the UK sectoral exemption and compensation eligibility criteria.

Carbon pricing through the EU Emissions Trading System (EU ETS) is another factor influencing retail electricity prices. The European Commission has issued guidelines⁹ on State aid measures aimed at reducing the indirect carbon costs faced by certain economic sectors. With the aim of avoiding distortions to competition in the internal market, the mechanism focuses on sectors at risk of carbon leakage when facing particularly high electricity prices. These cost reductions apply to only six Member States: the UK, Spain, Greece, Belgium, Germany and the Netherlands. As well as satisfying the requirements for exemptions on national taxes, most of the sectors in the UK that we considered in this analysis also receive carbon cost compensation.

2.5 Tax reduction mechanisms based on firm-specific characteristics

Whilst national policies for the UK and the State aid guidelines for the EU ETS both grant policy costs relief for a restricted list of sectors, in many of the other countries we considered, electricity cost reductions are defined by different eligibility criteria. For example, EU Member States such as France, Germany and the Netherlands introduced more complex mechanisms of progressive tax reductions based on firm-specific energy consumption patterns. In many cases, tax exemptions are defined by the scale of electricity consumption and/or electro-intensity¹⁰. In some cases, economic variables not directly

⁹ *Communication from the Commission of 5 June 2012 on Guidelines on certain State aid measures in the context of the greenhouse gas emission allowance trading scheme post-2012*. Available at: [http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012XC0605\(01\)&from=EN](http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012XC0605(01)&from=EN).

¹⁰ In Germany, for example, firms can pay a lower rate (0.3 €/MWh) for the combined heat & power generation surcharge if they consume over 0.1GWh electricity per year and electricity costs are over 4% of annual turnover. If the firm consumes over 0.1GWh electricity per year but the electricity costs are below 4% of annual turnover, then the policy rate is 0.5 €/MWh,

related to final user's consumption patterns (such as trade intensity) also determine eligibility for policy cost exemptions. For network charges, the number of consumption hours and time of consumption is also important in determining the network costs that a firm will face.

We defined three energy-intensive industry profiles for the comparison of international electricity prices. Table 2.4 summarises the main characteristics of the three industry profiles, in terms of annual electricity consumption, annual consumption hours, electro-intensity of output and grid connection, with Profile 1 reflecting relatively small electro-intensive industries and Profile 3 reflecting the largest, most electro-intensive industries. This industry profile classification is used to compare profile-specific electricity prices for international firms to sector-specific electricity prices in the UK. To take account of the existence of sector-specific exemptions to indirect carbon costs, two versions of the industry profiles were created: one version shows electricity prices for industries that face some exemptions to EU ETS costs and the other version shows the prices faced by industries that do not face EU ETS price exemptions.

Table 2.4 Consumption profiles: small, medium and large

	Profile 1 (Small)	Profile 2 (Medium)	Profile 3 (Large)
Annual consumption (GWh)	5	30	75
Annual consumption Hours	6240	7600	8736
Electricity use over added value	1 KWh per € of added value	2.7 KWh per € of added value	6.2 KWh per € of added value
Grid connection	Local Transmission System Operator (LTSO)	Transmission System Operator (TSO)	Transmission System Operator (TSO)

Source: Cambridge Econometrics.

The list of countries selected for the electricity price comparison includes EU Member States and key international competitors (China and the US). The industry profiles specified in Table 2.4 were used for the presentation of electricity prices in all countries, the only exemptions being the UK and China.

Categorisation of Chinese firms for electricity cost comparison

While a detailed list of industries is considered for the UK, Chinese firms are categorised into:

- Encouraged and permitted firms (face lowest level of tax and surcharges)
- Restricted firms
- Eliminated firms (face highest tax and surcharges)

This classification reflects the differentiated electricity pricing policy introduced by the Chinese National Development and Reform Commission (NDRC) in

2004. According to this program, particularly heavy power usage sectors are subject to punitive surcharges aimed at improving their energy efficiency or explicitly discouraging new investments in those sectors (Lo, 2014)¹¹. While important cost differentials exist among Chinese provinces, the punitive surcharge can be an important component of the final electricity price faced by electro-intensive industries.

2.6 Approach to estimating industry electricity prices

The first stage in estimating industry electricity prices involved estimating prices faced by a medium-sized industrial consumer¹² in 2016. We did not initially apply any exemptions or compensation to policy costs or network costs and we used this as our benchmark industry. For every country and every sector/industry profile, we then estimated the scale of exemptions and compensation for each cost component and applied these to derive electricity prices at a sectoral level¹³. This section outlines how we developed estimates for electricity prices by component part.

Electricity price components

The final electricity price faced by industrial customers can be broken up into the following price components:

- Wholesale electricity price
- Transmission and distribution (T&D) costs
- EU ETS costs
- Additional taxes and levies: for the UK, this includes Carbon Price Support (CPS), Climate Change Levy (CCL), and support for the Renewables Obligation (RO), Contracts for Differences (CfDs) and Feed-in-Tariffs (FiTs).

Notwithstanding differences in terms of taxes and policy costs structure, this decomposition applies to all countries considered in this study. The next section presents the details behind the calculation of each price component and the underlying assumptions.

Wholesale electricity prices

The first price component is the wholesale electricity price. It represents the price paid by large end-users who directly purchase energy from electricity generators and face lower overall electricity costs by avoiding the retail electricity market. The wholesale electricity price is influenced by three key factors:

- Global and regional fossil fuel prices
- The electricity generation mix

¹¹ Lo, K., 2014. A critical review of China's rapidly developing renewable energy and energy efficiency policies. *Renewable and Sustainable Energy Reviews*, 29(C), pp.508-516. Available at:

<http://www.sciencedirect.com/science/article/pii/S1364032113006655>.

¹² Consuming between 500 and 2,000MWh of electricity per year.

¹³ Wholesale electricity prices were also calibrated at a sectoral level.

- The merit order effect (MOE)

Increases in fossil fuel prices in recent years have put upward pressure on wholesale electricity prices. This has been partially negated by the dampening effect of increasing renewable electricity generation (through the merit order effect). Due to their low marginal costs, technologies like solar and wind enter the supply curve at a lower level, therefore reducing the employment of more expensive technologies and, ultimately, the wholesale electricity price.

To estimate the wholesale electricity price, for most countries, we used the long run marginal cost (LRMC) of gas, as we found that this provides a good approximation of wholesale electricity prices and is the price setter according to the merit order (see Appendix A for more information). In France, gas generation represents only 4% of total electricity generation and this share is expected to fall further, to less than 2% by 2030. It would therefore be unsuitable to use the wholesale gas price in France as a predictor of future electricity prices. Imports of electricity make up a relatively large share of total electricity supply in France (around 10% in 2013) and recent data shows that wholesale electricity prices in France and Germany are beginning to converge. Therefore, we used the wholesale electricity price in Germany to approximate the wholesale price faced by French industries over the period to 2030. In China, the long run marginal cost of coal was used to estimate the average wholesale price, as most of the electricity in China is produced by coal fired power plants and coal is the marginal fuel that sets the wholesale electricity price.

Overall, the LRMC calculation includes variable costs, such as the gas price and carbon cost, and fixed capital costs. Reductions in the wholesale electricity price because of the merit order effect (due to an increasing share of renewable electricity generation) are also deducted from the calculated value in each year. The merit order effect was estimated using 2030 estimates from Deane (2015)¹⁴.

Transmission and distribution costs

The transmission and distribution cost component includes the charges paid by final customers for the operation and maintenance of the high voltage transmission system which transports electricity from power plants to national distribution networks and then distributes to final consumers to meet their demand. Some of the large end-users are directly connected to the transmission network, therefore avoiding distribution charges.

The Eurostat database provides annual data on electricity price components for industrial customers by country. To estimate the network costs faced by each sector and profile, we used the 2015 Eurostat network costs of the corresponding consumption category. In doing so, we introduced an adjustment to account for differences in transmission and distribution costs for different sizes of industrial customer. It is noted that there are some

¹⁴ Deane, P. (2015), 'Quantifying the "merit-order" effect in European electricity markets'. Available online at: http://insightenergy.org/system/publications/files/000/000/013/original/RREB_III-Merit_order_Final.pdf?1435070717

inconsistencies in the Eurostat data for network costs, when compared to other data sources and these inconsistencies are discussed in more detail in 1.11.1.1.1.Appendix B.

Network charges vary according to the electricity consumption level and any specific exemptions¹⁵ in place. In general, these charges are lower for large industrial users. The transmission and distribution cost data available from Eurostat at the time of this study, was limited to the year 2015 and we assumed T&D costs would increase in the future to account for additional grid costs associated with a higher share of intermittent renewables. We applied an intermittency cost of £10/MWh of additional renewable generation. This is based on ranges presented in a recent IEA publication¹⁶, and analysis by Imperial College London for the CCC¹⁷. Additional grid support to deal with intermittent renewables represents a small but increasing cost, as the share of electricity generation from wind, solar and other renewables is projected to increase in all the selected countries.

While the Eurostat database is the main source of network costs data for the EU Member States, average transmission and distribution costs from the Public Utility Commission of Texas (PUC) were used as a proxy for network charges in the United States. Similarly, network costs for the Shenzhen city in the Guangdong region were used as a proxy for the costs faced by Chinese industries. Located in the south-eastern part of China, this region is one of the most economically developed in the country. The city of Shenzhen has also been one of the test locations for the upcoming electricity market reform developed by the Chinese government in the 13th Five-Year Plan.

Carbon costs

The indirect carbon cost forms another component of the total electricity price in the EU Member States. This cost was estimated using the carbon intensity of gas generation in each country, consistent with the calculation of the wholesale electricity price based on the long run marginal cost of gas. This estimation is initially used to estimate the carbon cost for an industry not benefiting from compensation in any of the considered years. However, given the existence of sectoral compensation in certain countries, a detailed analysis and literature review was undertaken to assess individual policy costs in each country. In this case, the calculation of the carbon cost was based on the

¹⁵ It is unclear to what extent these exemptions are taken account of in the Eurostat data that our estimates are based on.

¹⁶ IEA-ETSAP and IRENA (2015), 'Renewable Energy Integration in Power Grids'. Available online at: http://www.irena.org/DocumentDownloads/Publications/IRENA-ETSAP_Tech_Brief_Power_Grid_Integration_2015.pdf

¹⁷ Imperial College London and NERA Economic Consulting (2015), 'Value of Flexibility in a Decarbonised Grid and System Externalities of Low-Carbon Generation Technologies'. Available online at: https://www.theccc.org.uk/wp-content/uploads/2015/10/CCC_Externalities_report_Imperial_Final_21Oct20151.pdf

carbon intensity of national fossil fuels generation as required by the EU Guidelines on aid measures for the indirect carbon costs of the EU ETS¹⁸. Among the considered countries, the UK grants compensation for the indirect carbon costs of the EU ETS and for the indirect carbon costs of carbon price support mechanism according to the same parameters, such as the electricity consumption efficiency and the aid intensity. The same system of compensation is provided in Germany, Belgium (Flanders) and the Netherlands but regarding only the indirect carbon costs due to the EU ETS. Across the considered sectors, the following industries are eligible for compensation:

- Steel EAF
- Steel BOF
- Fertilisers and nitrogen compounds
- Aluminium production
- Paper and paper products

Taxes and policy costs

The last component of the electricity price is represented by taxes and other policy costs charged to final electricity consumers. This category comprises all the additional costs imposed on energy end-users to finance various activities at the national level. These surcharges are generally used to finance measures supporting renewable energy production, paying energy sector pensions, financing regional projects and compensating network costs exemptions. The costs vary considerably in terms of their contribution to total electricity costs across countries.

The different policy costs were estimated for each sector or profile and regulated-by-law category before and after including exemptions. While for the UK we assessed policy cost exemptions and compensation at the sectoral level, they were estimated for three different industry size bands in the EU comparator countries, two consumption categories in the US and three categories in China. We assessed the tax reductions for the three electricity consumption profiles. The considered policy costs are all applied at the national level with the exception of the US, where only Texan taxes and levies were included. Besides national policies, energy-intensive firms in Belgium are also subject to additional regional costs. Among these, only the charges applied in the region with the highest concentration of energy-intensive industries, Flanders, were considered. Table 2.5 and Table 2.6 summarise, for each country, policy costs and network costs exemptions identified in the literature review.

¹⁸ *Communication from the Commission of 5 June 2012 on Guidelines on certain State aid measures in the context of the greenhouse gas emission allowance trading scheme post-2012*. Available at: [http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012XC0605\(01\)&from=EN](http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012XC0605(01)&from=EN).

Table 2.5 Policy costs and relative exemptions by country (€/MWh)

Country	Policy Costs	€/MWh (2016)	Exemptions
United Kingdom	Climate Change Levy (CCL)	5.52	Metallurgical and mineralogical processes are fully exempt. Other sectors received a 90% discount on the CCL rate for electricity (and 65% discount on the CCL rate for gas).
	Contracts for Difference (CfD)	1.24	While exemptions from the CfD have not yet come into force, we assume that all the sectors will benefit from an 85% reduction in 2020 and 2030, the only exception being Fabricated Metals (0%)
	Renewables Obligation (RO)	11.59	We assume that all the firms in the considered sectors satisfy (and will satisfy in the following years) the electricity intensity test and, therefore, benefit from an 85% reduction, the only exception being Fabricated Metals (0%)
	Feed-in Tariffs (FiT)	3.63	We assume that all firms in the considered sectors satisfy (and will satisfy in the following years) the electricity intensity test and, therefore, benefit from an 85% reduction, the only exception being

			Fabricated Metals (0%)
Belgium	Financing of connection of offshore wind power generation units	0.06	If part of an energy efficiency agreement, consumers can benefit from the following reductions: -15% if consuming 20-50 MWh/year, -20% if consuming 50-1,000 MWh/year, -25% if consuming 1,000-25,000 MWh/year, -45% if consuming > 25,000 MWh/year (capped at 250,000 €/year)
	Financing of federal green certificates	3.83	Assume no exemptions for the profiles considered due to insufficient information for quantification.
	Financing of strategic reserves	1.00	None
	Financing of support measures for renewable energy and cogeneration	0.76	To be paid only in Flanders and if connected to a local transmission service operator. Industries in Flanders can benefit from the following reductions: -47% if consuming 1,000-20,000 MWh/year, -80% if consuming 20,000-250,000 MWh/year, -98% if consuming > 250,000 MWh/year
	Financing measures for the promotion of rational users	0.06	To be paid only in Flanders and if connected to a local

			transmission service operator
	Federal contribution	3.04	If part of an energy efficiency agreement, consumers can benefit from the following reductions: - 15% if consuming 20-50 MWh/year, -20% if consuming 50-1,000 MWh/year, -25% if consuming 1,000-25,000 MWh/year, -45% if consuming > 25,000 MWh/year (capped at 250,000 €/year)
	Levy for the taxes “pylons” and “trenches”	0.10	To be paid only in Flanders from 2016.
Germany	Combined heat & power generation surcharge (CHP)	4.45	0.3 €/MWh if consumption > 0.1 GWh / year and electricity cost > 4% of annual turnover, 0.4 €/MWh if ONLY consumption > 0.1 GWh / year
	StromNEV 19-Umlage	3.78	0.25 €/MWh if consumption > 1 GWh / year and electricity cost > 4% of annual turnover, 0.5 €/MWh if ONLY consumption > 1 GWh / year
	Offshore liability overload	0.40	0.25 €/MWh if consumption > 1 GWh / year and electricity cost > 4% of annual turnover, 0.27 €/MWh if ONLY consumption > 1 GWh / year

	eEG-Umlage	63.54	For consumption exceeding 1 GWh / year, customers benefit at least an 85% reduction: 9.53 €/MWh if electricity cost is 17% or 20% > gross value creation (% dependant on sector) but capped at: 0.5% of gross value creation if electricity cost > 20% of gross value creation; 4% of gross value creation if electricity cost < 20% of gross value creation. Bottom rate at 0.5 €/MWh
	Stromsteuer (electricity tax)	20.50	Industrial customers pay a lower rate (15.37 €/MWh) and they can benefit a further reduction up to 90% depending on pension contributions paid by the company ¹⁹ . A number of sectors are also exempt from this charge.
	Konzessionsabgabe (concessions)	1.10	100% exemption if final electricity price is lower than 132.27 €/MWh
France	Contribution tarifaire d'acheminement (CTA)		If directly connected to the transmission grid or to the distribution grid above 50 kV, CTA amounts to 10.14% of the fixed part of the transmission tariff, otherwise 27.07%

¹⁹ Additionally, electricity used as raw material in electro-intensive industrial processes is totally exempt.

	Contribution au service public d'électricité (CSPE)	22.50	<p>If CSPE = 0.5% of added value (without reductions and exemptions), the following tariffs apply:</p> <p>2 €/MWh if consuming > 3 KWh per € of added value,</p> <p>5 €/MWh if consuming between 1.5 and 3 KWh per €,</p> <p>7.5 €/MWh if consuming less than 1.5 KWh per €. The tariff is 0.5 €/MWh if consuming > 6 KWh per € and trade intensity > 25% (very electro-intensive consumers). Sectors at risk of carbon leakage (metallurgy, electrolysis, non-metal minerals and chemicals) face the following tariffs: 1 €/MWh if consuming > 3 KWh per €, 2.5 €/MWh if consuming between 1.5 and 3 KWh per €, 5.5 €/MWh if consuming < 1.5 KWh per €</p>
Netherlands	Belasting op elektriciteit (electricity tax)	100.70	<p>The following rates apply: 49.96 €/MWh if consuming 10 to 50 MWh per year; 13.31 €/MWh if consuming 50 to 10,000 MWh per year; 0.53 €/MWh if consuming > 10,000 MWh per year</p>

	ODE levy (promotion of renewables)	5.60	The following rates apply: 7 €/MWh if consuming 10 to 50 MWh per year, 1.9 €/MWh if consuming 50 to 10,000 MWh per year, 0.084 €/MWh if consuming > 10,000 MWh per year. 100% exemption if electricity is used for chemical reduction, electrolytic and metallurgic processes
Ireland	Public service obligation levy (PSOL)	64.37	34.20 €/kVA applies to medium and large customers (if max import capacity >30kVA)
China	Punitive electricity surcharge	55.56	The following rates apply: 0 €/MWh if permitted or encouraged category, 12.27 €/MWh if restricted category, 55.56 €/MWh if eliminated category
	Promotion of renewable energies	1.15	None
	Promotion of agriculture and network expansion	2.58	None
	Promotion of a hydropower project	0.92	None
	Surcharge to finance desulfurisation of coal-fired power plants	1.94	None
United States	Energy efficiency cost recovery factor		Lower rates for the secondary sector > 10 KW
	Competition transition charges		Lower rates for industrial power and secondary sector > 10 KW

Source: Cambridge Econometrics based on PwC, ECOFYS, NDRC and PUC.

Table 2.6 Transmission and distribution exemptions by country for Profile 2 and 3

Country	T&D exemptions
Germany	If consumption > 10 GWh / year, the following exemptions apply: 80% if > 7000 yearly consumption hours, 85% if > 7500 yearly consumption hours, 90% if > 8000 yearly consumption hours
France	The following maximal reductions can apply: 60% if consuming > 2.5 KWh per € of added value and trade intensity > 4%; 90% if consuming > 6 KWh per € and trade intensity > 25%
Netherlands	A maximum reduction of 90% applies if consuming > 50 GWh / year and at least during 65% of all 2920 off-peak hours per year
United States	Tariffs vary by power company

Source(s): PwC, own analysis.

Calibration to historical data

We applied a calibration factor to match our estimates to the most recently published electricity price data in each country. The purpose of the calibration was to align our estimates to real data, to correct for error in the use of the long run marginal cost of gas as a proxy for the wholesale price. The calibration factor was calculated for 2015 electricity prices²⁰ and we assumed the same prediction error (in absolute terms) going forwards for the construction of estimates in 2020 and 2030. Table 2.7 shows the calibration factors that were applied to wholesale electricity prices in the UK.

²⁰ Wholesale electricity price data from Eurostat was only available for years up to 2015 at the time of undertaking this study and the calibration factor was therefore calculated using electricity prices for 2015.

Table 2.7 Calibration factors applied to UK industries (£/MWh)

	Profile category	Wholesale price calibration factor (£/MWh)
Medium-sized firm ²¹	Before exemptions	14.8
Fabricated metals	Profile 1	8.9
Ceramics		8.9
Plastic products		8.9
Fertilisers	Profile 2	8.6
Paper and pulp		8.6
Glass		8.6
Steel EAF	Profile 3	7.9
Steel BOF		7.9
Industrial gases		7.9
Cement		7.9
Aluminium		7.9

Notes: Prices are calibrated in two stages: firstly, the wholesale electricity price is calibrated to published data, then the retail electricity price is calibrated (after network costs and estimated policy costs are added).

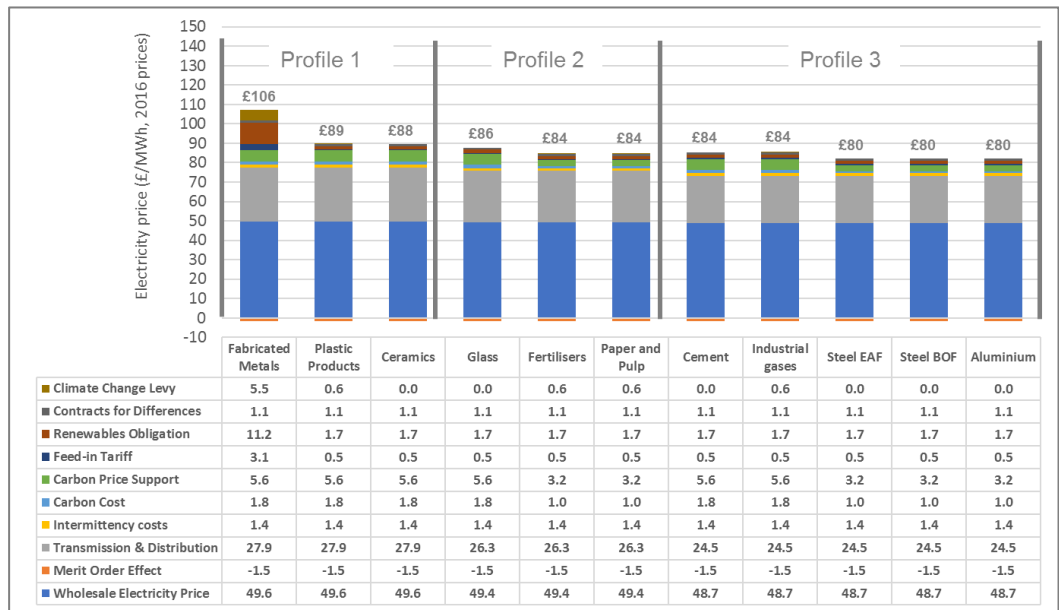
Source: CE.

2.7 Results for electricity prices faced by energy-intensive industries in the UK

For the UK, we provide a detailed breakdown of industrial electricity price components for each energy-intensive industry. Figure 2.1 shows the estimated electricity prices for each energy-intensive sector in 2016. The price varies across sectors according to the policy costs and exemptions granted to that sector. The estimated wholesale price, merit order effect and the applied calibration factor are assumed to be the same across all sectors. Consistent with published Eurostat data, transmission and distribution costs are slightly lower for the most energy-intensive industries (categorised as Profile 3).

²¹ Consuming between 500 and 2,000MWh of electricity per year.

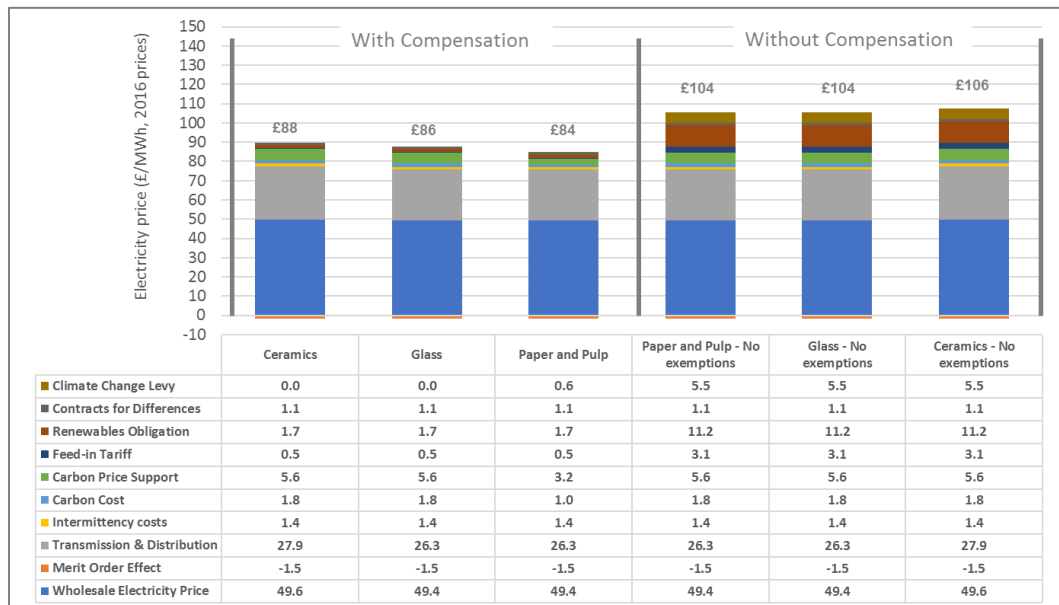
Figure 2.1 UK 2016 industry electricity prices broken down by component



Notes: The merit order effect shows the impact of an increasing share of zero-marginal cost renewables in the electricity grid and has a small negative impact on the wholesale electricity price. For the international price comparisons, the wholesale electricity price is presented net of this effect. The wholesale price is calibrated to historical data.

Source: Cambridge Econometrics.

Figure 2.2 UK 2016 industry electricity price for Ceramics, Glass and Paper sector (with and without policy cost relief)



Notes: The merit order effect shows the impact of an increasing share of zero-marginal cost renewables in the electricity grid and has a small negative impact on the wholesale electricity price. For the international price comparisons, the wholesale electricity price is presented net of this effect.

Source: Cambridge Econometrics.

Of all the sectors considered, 'Fabricated metals' face the highest cost per MWh of electricity consumed, as the sector is ineligible for any policy exemptions. As most of the other sectors benefit from some cost reductions, the price differential among them was not as large. The Climate Change Levy (CCL) did not affect the electricity price for most of the electro-intensive industries considered, where 90% or 100% exemptions are granted. Similar compensation is in place for the Renewables Obligation (RO) and Feed-in Tariffs (FiT), as such these policies have only a marginal impact on the final price faced by these industries. As only five of the listed sectors were entitled to indirect carbon cost compensation, the EU ETS cost and the Carbon Price Support scheme (CPS) cost combined, had a greater effect on electricity prices, adding £7.4/MWh to the electricity price for the 'Cement', 'Industrial gases', 'Glass', 'Plastics', 'Ceramics' and 'Fabricated Metals' sectors. The estimated merit order effect in 2016 reduced electricity prices by £1.5/MWh. Figure 2.3 shows that the wholesale price and network costs are the largest components in the price, together accounting for 70-90% of the total price. Overall, the system of sectoral relief means that the cost associated with financing UK low-carbon policy is a relatively small component of electricity prices for electro-intensive sectors (as little as 10% for the most electro-intensive).

As well as estimating electricity prices in 2016, we project sectoral electricity prices in the future. In the previous case, the price is presented as the sum of future policy costs, wholesale prices, network charges and the merit order effect (see Figure 2.2).

Figure 2.3 UK 2030 industry electricity prices broken down by component



Source: Cambridge Econometrics.

By 2030, the final price is projected to increase for all the industries considered, predominantly due to expected increases in the wholesale electricity price (accounting for 60-90% of the increase) and policy costs (accounting for 10-40% of increase). Our estimates suggest that all the sectors considered will be paying more than £100/MWh by 2030. Profile 1 industries, especially 'Fabricated metals', will still face higher costs than the other industry profiles. While the absolute value of tax and levies is expected to increase, these costs still only account for a small portion (around 15-20%) of the final price. By 2030, the carbon price and CPS scheme costs are expected to be considerably more expensive for energy-intensive industries due to an increased carbon price. In most of the sectors, these costs add around £8/MWh to £20/MWh to the final price. However, the transmission and distribution costs and the wholesale price continue to be the largest cost components, together making up over 80% the final electricity price.

2.8 A comparison among industrial profiles

Electro-intensive industries are subject to a variety of taxes and levies in the countries considered. For many countries, these policy costs can significantly increase total energy expenditures of the manufacturing sector. This section presents a comparison of electricity prices between UK sectors and the corresponding industry profiles in competing countries, focusing on the main determinants of the final price: the wholesale price, network costs, the carbon cost and other policy support costs. The results are presented for a central scenario for both the carbon cost and fossil fuel prices, based on BEIS projections²².

Figure 2.4 compares the projected evolution of electricity prices in different countries for a medium-sized industry that does not benefit from any form of exemption²³. The increase in the electricity price over time reflects an increase in the wholesale electricity price (due to an increase in the long run marginal cost of fossil fuel based generation) and an increase in policy support for renewables (reflecting higher shares of renewable capacity over the projection period).

With the exception of China,²⁴ electricity prices are expected to increase over the period to 2030 for all other countries considered. Our bottom-up calculations suggest that UK electricity prices for medium-sized firms are higher than in all other countries considered. Industries in the US and the Netherlands will continue to face a lower price than in other countries. Based on our estimates, where we assume that renewable policy costs grow in line with total renewable generation, the UK sees among the highest growth in

²² BEIS (2016), 'Updated Energy Projections'

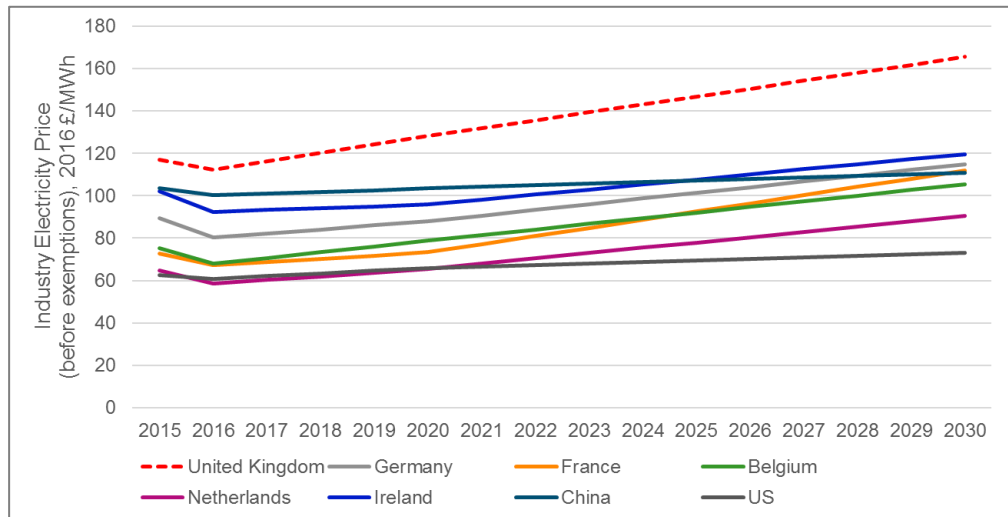
²³ Reflective of a medium-sized industry consuming 500MWh-2GWh electricity per year.

²⁴ Figure 2.4 depicts the electricity price evolution for an industry classified as "eliminated" in China.

Electricity prices in China remain stable in real terms, due to a stable coal price (which we assume is the price setter in this case) and because renewable and other policy costs only make up a small share of the final electricity price.

electricity prices and, by 2030, we expect industries based within the UK will face the highest before-reliefs electricity prices when compared to those in key trade partner countries. French, Belgian and Irish industries are expected to pay a similar price in 2030. The projected paths are the result of anticipated increases in wholesale prices, carbon costs and other policy costs.

Figure 2.4 Electricity price projections for a medium-sized benchmark industry (consuming 500 MWh to 2 GWh electricity per annum)



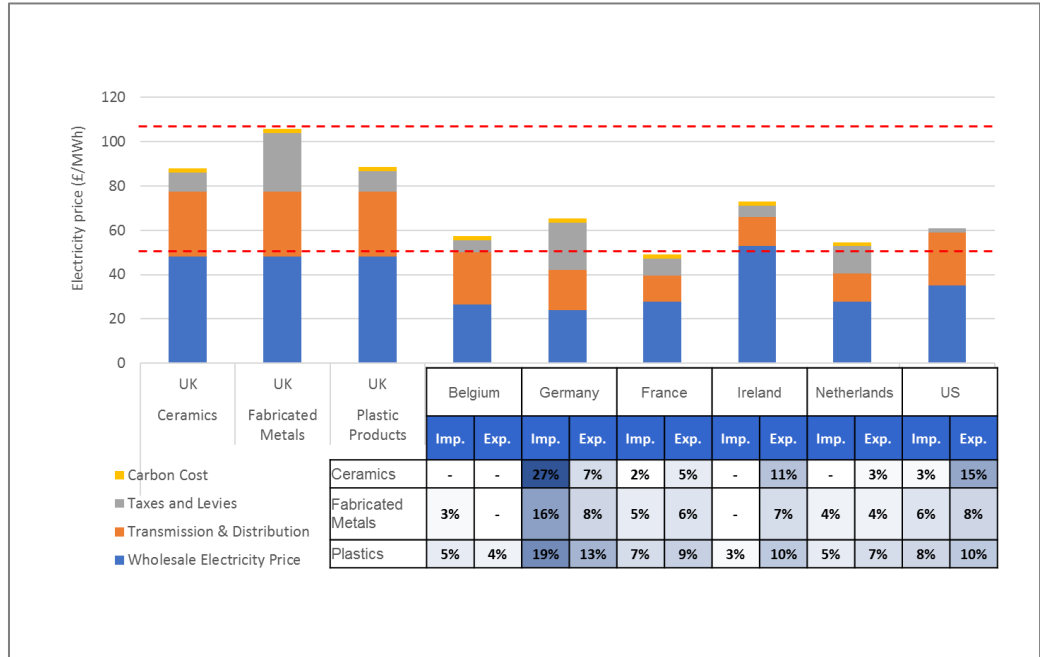
Notes: For China, the electricity price reflects those for an 'eliminated' firm, facing the highest prices and surcharges of all Chinese industries.

Source: Cambridge Econometrics.

Profile 1 industries

Profile 1 industries are the least electro-intensive of the sectors considered and consume less than 10GWh of electricity per annum. In the UK, the sectors that fall under this category include, 'Fabricated metals', 'Plastic products' and 'Ceramics'. The price comparison revealed large differences in the national electricity prices faced by Profile 1 industries. Wholesale prices, network costs and other taxes and levies varied highly across nations. The wholesale price continued to be the main determinant of the final price, while the carbon cost played a marginal role. Profile 1 industries do not receive any indirect carbon cost reduction. Electricity prices for the UK 'Ceramics' and 'Plastic products' sectors are around £20/MWh higher than those faced by Profile 1 industries in the other comparator countries. The final price for the UK Fabricated metal sector was estimated to be highest of all sectors/countries considered, at over £100/MWh. Due to very low wholesale and network costs, the electricity price in France is the most competitive, closely followed by the Netherlands and the US.

Figure 2.5 Electricity prices for Profile 1 industries, 2016



Notes: Dashed red lines show minimum and maximum electricity prices faced by Profile 1 industries across all countries considered. The table under the chart shows, for each sub-sector, the share of total imports and total exports to the UK that is attributable to each partner country.

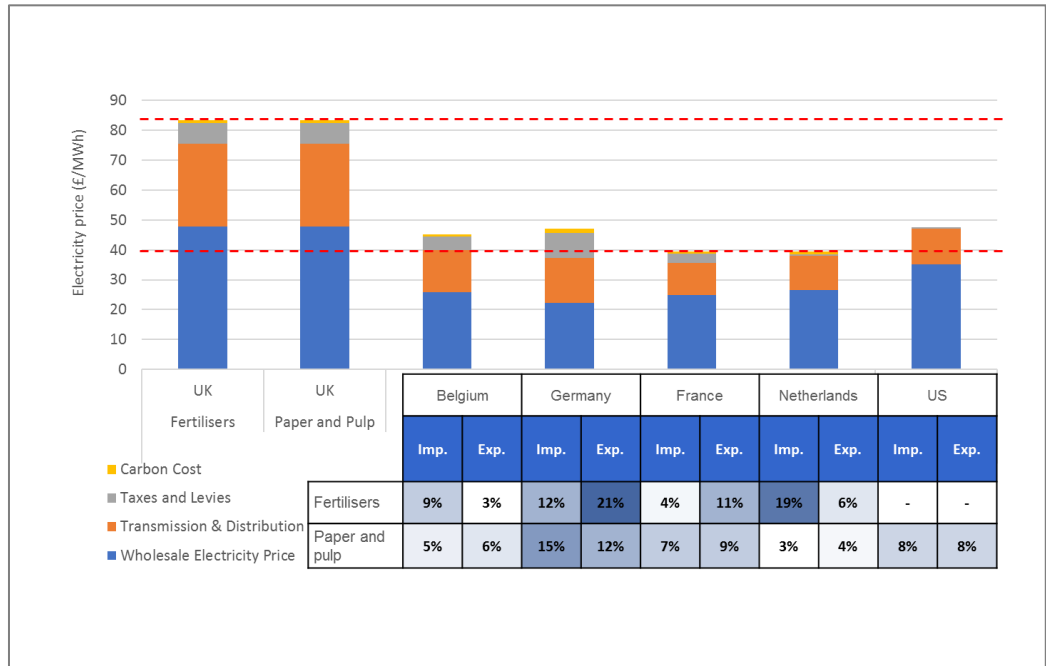
Source: Cambridge Econometrics.

Profile 2 industries

Profile 2 industries consume 10 to 50GWh of electricity per annum and are twice as electro-intensive as Profile 1 industries. The results show that industries consuming higher amounts of electricity benefited from reductions in transmission and distribution and other policy costs. As a result, in 2016, UK firms were paying a maximum of about £83/MWh (as shown in Figure 2.6) compared to around £90/MWh - £105/MWh paid by a Profile 1 firm in the UK (as shown in Figure 2.5). Nevertheless, according to Eurostat data, the reduction in network costs was small compared to other key competitors, therefore offsetting the induced competitive advantage. Figure 2.7 shows how some of them also received state aid to limit the indirect carbon cost.

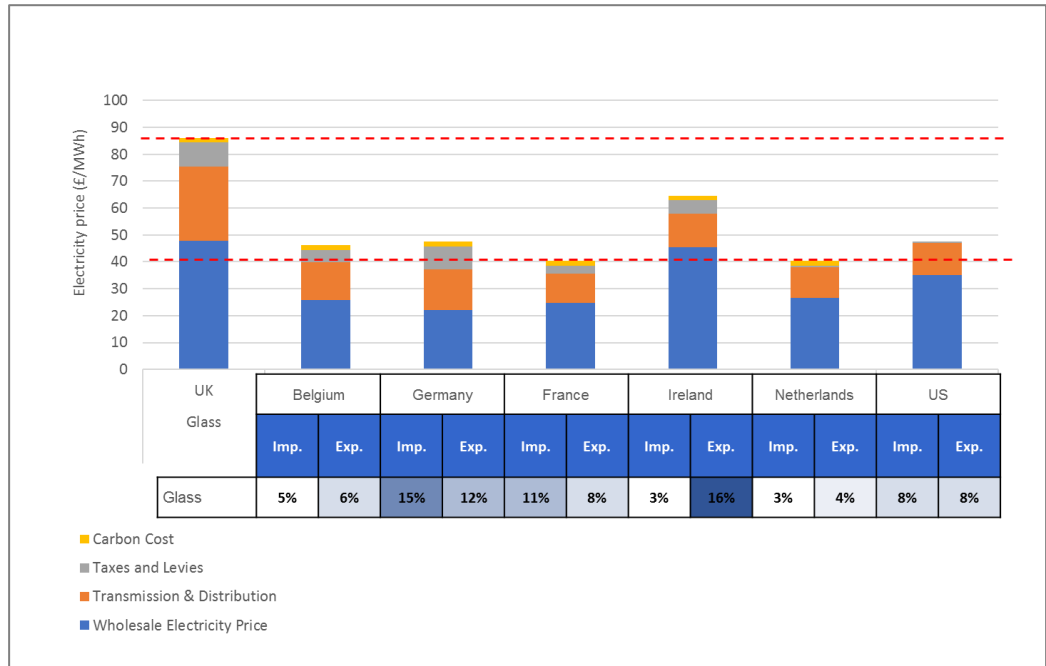
Overall, the international comparison depicted by Figure 2.6 and Figure 2.7 reveal similar results as for the Profile 1 case. UK industries still paid higher electricity prices than their international competitors. In a key export market, Ireland, local industries were facing a slightly lower electricity price than in the UK (around £15/MWh lower). France and the Netherlands offered the lowest prices in Europe. The high trade intensity and significant share of imports of manufactured products from countries facing relatively low electricity prices (such as the US, France, Netherlands and Belgium) suggest that UK Profile 2 industries are more exposed to competitiveness risks than Profile 1 industries.

Figure 2.6 2016 electricity prices for Profile 2 industries with EU ETS exemptions



Notes: Dashed red lines show minimum and maximum electricity prices faced by Profile 2 industries across all countries considered. The table under the chart shows, for each sub-sector, the share of total imports and total exports to the UK that is attributable to each partner country. Source: Cambridge Econometrics.

Figure 2.7 2016 electricity prices for Profile 2 industries without EU ETS exemptions



Notes: Dashed red lines show minimum and maximum electricity prices faced by Profile 2 industries without carbon cost compensation across all countries considered. The table under the chart shows, for each sub-sector, the share of total imports and total exports to the UK that is attributable to each partner country.

Source: Cambridge Econometrics.

Profile 3 industries

Profile 3 industries are the most energy-intensive and consume over 50GWh of electricity per annum. In 2016 these industries faced lower electricity prices than their smaller counterparts, and the final electricity price in the UK was around £80/MWh in 2016.

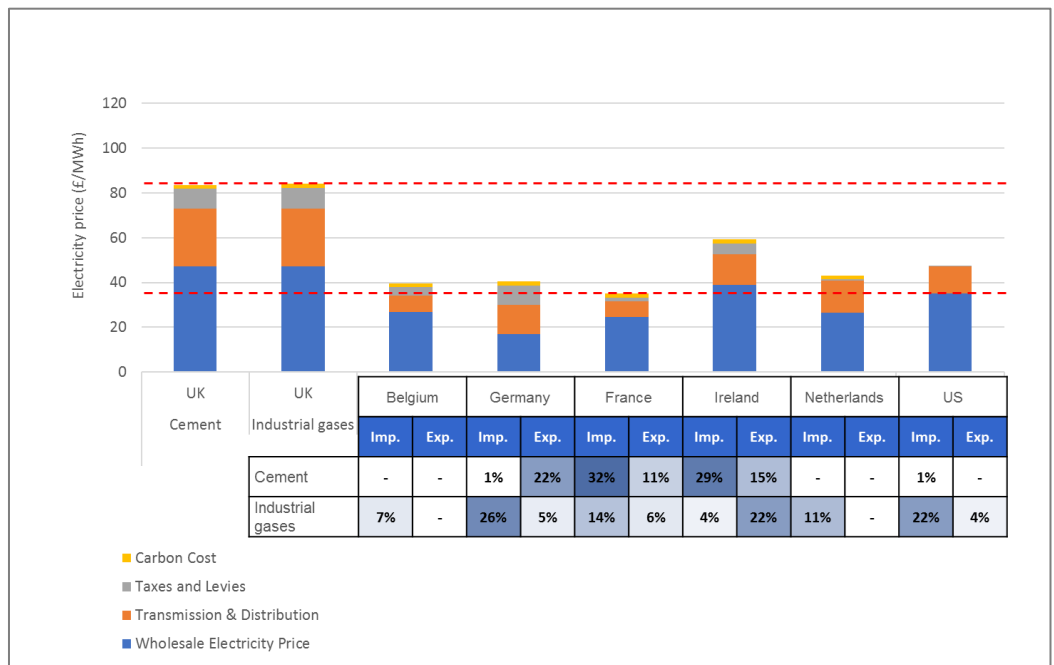
The wholesale electricity price and network costs represented an important component of the final electricity price (accounting for around 90% of the electricity price faced by UK Aluminium and Steel plants). Substantial low-carbon policy cost exemptions apply in the UK, but even with 100% exemption, overall prices in the UK would be higher than those in comparator countries, due to the higher wholesale price and network charges. Electricity prices for Profile 3 industries in the UK were around £40/MWh higher than in the Netherlands, Belgium and France and Germany. The price differential with the US was around £35/MWh and increases for the sectors without any carbon cost reductions. In other European Member States, Profile 3 sectors benefited from lower network costs and tax reductions.

Figure 2.8 Electricity prices for Profile 3 industries with EU ETS exemptions, 2016



Notes: Dashed red lines show minimum and maximum electricity prices faced by Profile 3 industries across all countries considered. The table under the chart shows, for each sub-sector, the share of total imports and total exports to the UK that is attributable to each partner country. Source: Cambridge Econometrics.

Figure 2.9 2016 electricity prices for Profile 3 industries without EU ETS compensation



Notes: Dashed red lines show minimum and maximum electricity prices faced by Profile 3 industries across all countries considered. The table under the chart shows, for each sub-sector, the share of total imports and total exports to the UK that is attributable to each partner country. Source: Cambridge Econometrics.

Figure 2.10 and Figure 2.11 show projected electricity prices in 2030 for Profile 3 firms. Compared to the 2016 results, the carbon cost forms a much larger part of the final electricity price, due to the projected increase in the EU ETS carbon price and reduced compensation. Facing low policy costs and no carbon costs, US companies continue to benefit from lower electricity costs compared to the other competitor countries in the projected period. Higher wholesale prices also drive an increase in the overall price and, again, US industries benefit from a lower wholesale gas price (according to the IEA projections) and, therefore, lower wholesale electricity prices. Industrial electricity prices in the UK remain the highest among the considered countries, largely a reflection of higher wholesale and network costs.

Figure 2.10 2030 electricity prices for Profile 3 industries with EU ETS compensation



Notes: Dashed red lines show minimum and maximum electricity prices faced by Profile 3 industries across all countries considered. The table under the chart shows, for each sub-sector, the share of total imports and total exports to the UK that is attributable to each partner country.

Source: Cambridge Econometrics.

Figure 2.11 2030 electricity prices for Profile 3 industries without EU ETS compensation



Notes: Dashed red lines show minimum and maximum electricity prices faced by Profile 3 industries across all countries considered. The table under the chart shows, for each sub-sector, the share of total imports and total exports to the UK that is attributable to each partner country.

Source: Cambridge Econometrics.

A comparison with China

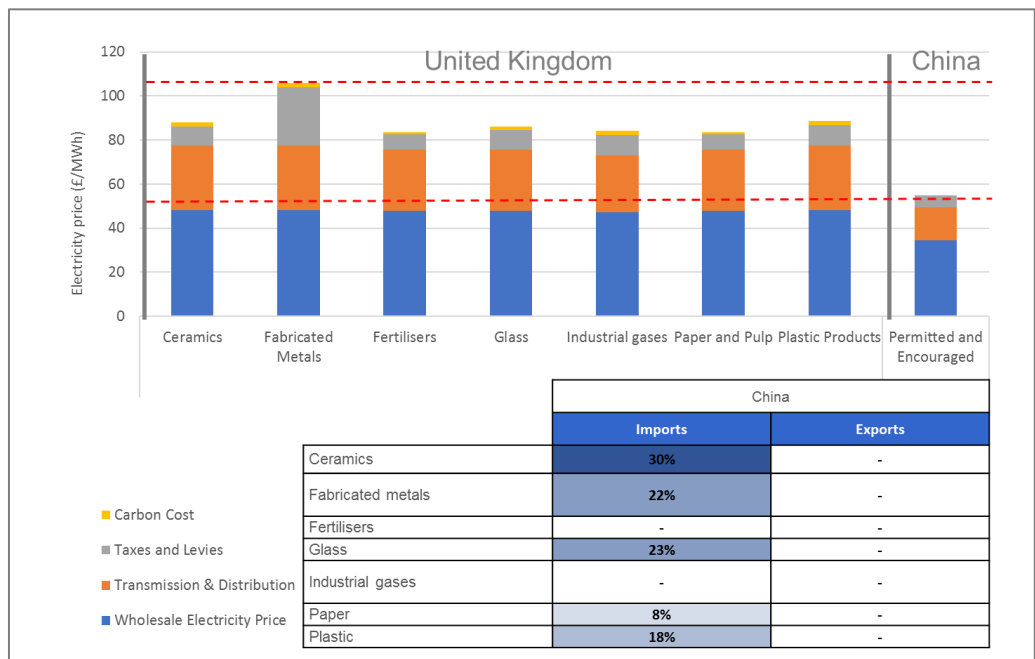
In 2004 the National Development and Reform Commission introduced a differentiated electricity price reform to improve the energy efficiency of very electro-intensive sectors in China. Firms in the manufacturing sector were classified into four different categories, namely the ‘encouraged’, ‘permitted’, ‘restricted’ and ‘eliminated’ categories. While no economic advantage was granted by the central government to the ‘encouraged’ and ‘permitted’ industries, the ‘restricted’ and ‘eliminated’ firms were charged an additional punitive surcharge. This tax was then increased in the following years and sometimes also at the provincial level. Nowadays, the punitive surcharge is applied to a number of production plants in the Aluminium, Steel and Cement sectors.

This section compares electricity prices in UK sectors and the four mentioned Chinese categories in 2016 and 2030. The following key messages emerged:

- China represents an important source of imports for most of the UK sectors included within the scope of this analysis
- Excluding the punitive surcharge, the amount of other policy costs imposed by the central government on the manufacturing sector is much lower than in the UK
- Lower network costs and wholesale prices lead to a lower industrial electricity price in China for the permitted and encouraged categories in 2016 and 2030

- When compared to Profile 3 sectors, ‘restricted’ and ‘eliminated’ firms face a substantial punitive surcharge, which leads to the overall electricity price for these firms in China exceeding UK prices
- Contrary to what happened in the other considered countries, the punitive surcharge becomes the main determinant of the final electricity price for eliminated electro-intensive industries

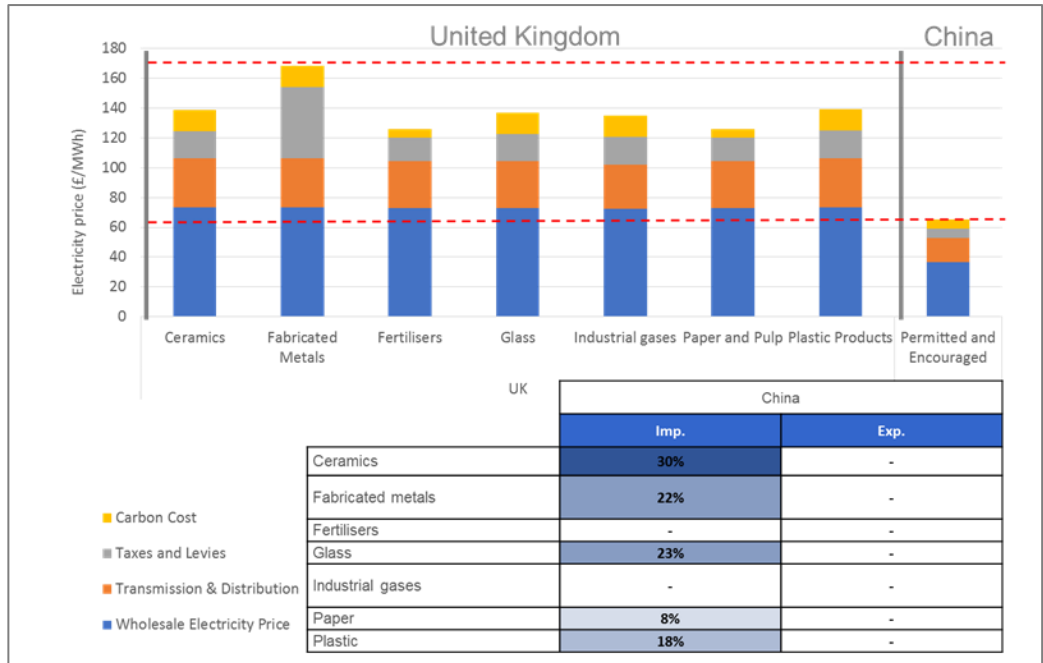
Figure 2.12 2016 electricity prices in the UK and corresponding permitted and encouraged plants in China



Notes: Dashed red lines show minimum and maximum electricity prices faced by industries in the UK and China. The table under the chart shows, for each sub-sector, the share of total imports and total exports traded between the UK and China.

Source: Cambridge Econometrics.

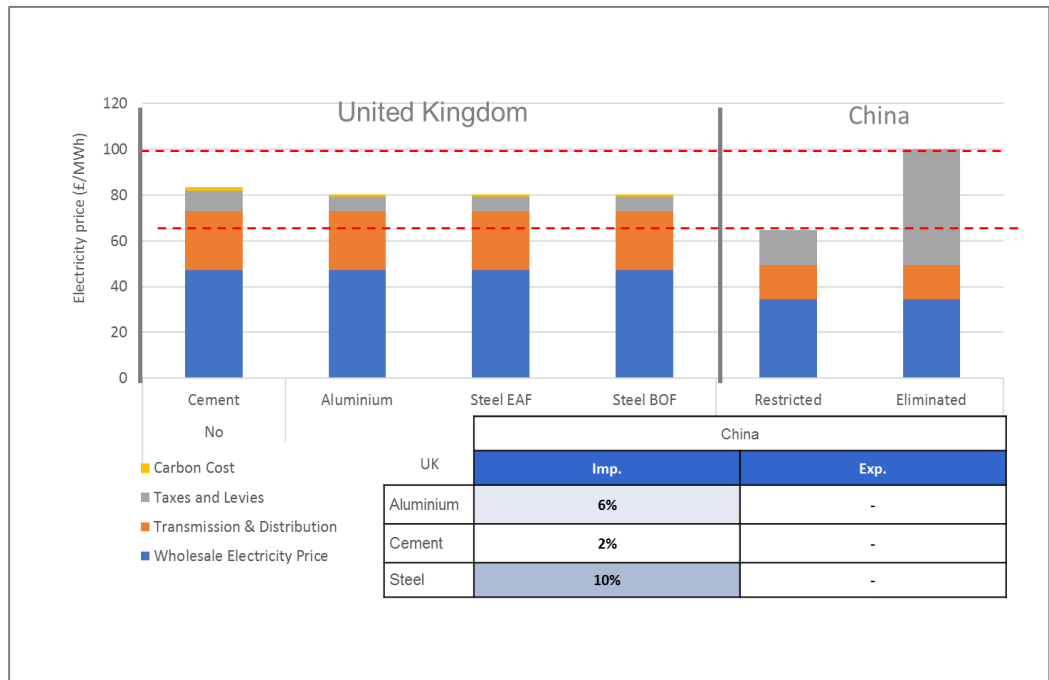
Figure 2.13 2030 electricity prices in the UK and corresponding permitted and encouraged plants in China



Notes: Dashed red lines show minimum and maximum electricity prices faced by industries in the UK and China. The table under the chart shows, for each sub-sector, the share of total imports and total exports traded between the UK and China. We assume that a carbon price is introduced in China from 2020 onwards.

Source: Cambridge Econometrics.

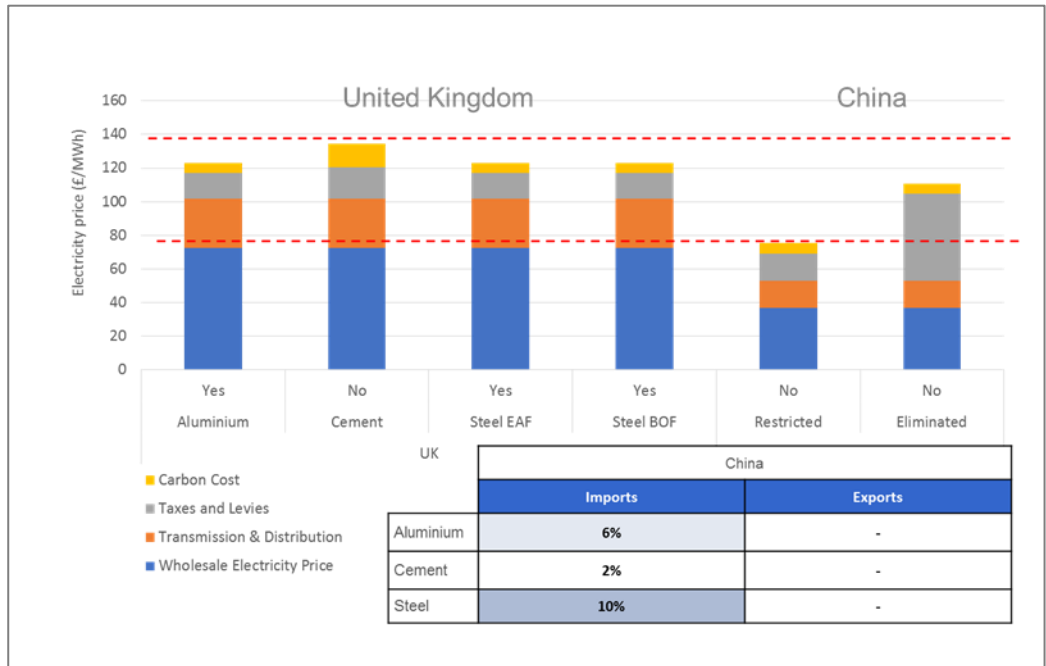
Figure 2.14 2016 electricity prices in the UK and corresponding restricted and eliminated plants in China



Notes: Dashed red lines show minimum and maximum electricity prices faced by industries in the UK and China. The table under the chart shows, for each sub-sector, the share of total imports and total exports traded between the UK and China.

Source: Cambridge Econometrics.

Figure 2.15 2030 electricity prices in the UK and corresponding restricted and eliminated plants in China



Notes: Dashed red lines show minimum and maximum electricity prices faced by industries in the UK and China. The table under the chart shows, for each sub-sector, the share of total imports and total exports traded between the UK and China. We assume that a carbon price is introduced in China from 2020 onwards.

Source: Cambridge Econometrics.

3 Industrial EU ETS allowances

3.1 Key Messages

- 1 The European Union introduced an emissions trading system (EU ETS) in 2005, issuing allowances (EUAs) to emit each tCO₂e to energy-intensive installations. This analysis looks at the under- or over-allocation of EU ETS permits and the net value of this allocation to a selection of UK industries both historically and into the future, under the following assumptions:
 - (a) constant levels of production and emissions;
 - (b) four variations of possible future carbon prices; and
 - (c) three policy scenario variations for the distribution of allowances to sectors considered at risk of carbon leakage.
- 2 For all sectors, the analysis shows the same broad pattern of over-allocation historically: in Phase I of the EU ETS the allocation is broadly in line with outturn emissions. For Phase II there was a substantial over-allocation, albeit with a relatively low value because of the low carbon price at the time; the financial crisis strongly affected output/emissions during this Phase. So far in Phase III the tightening of allocations has meant that they are well aligned with industry emissions, trending towards under-allocation as the allocation is reduced each year.
- 3 Looking to the future, all sectors can expect to receive allowances lower than recent verified emissions in Phase IV of the EU ETS.
- 4 The relative size and value of the allocation deficit changes markedly depending on the sector, the proposed method of allocating permits and the carbon price projection:
 - (a) For steel, considered at high risk of leakage in both tiered proposals, the EC's binary proposal would have the most detrimental effect due to the different benchmarks proposed for allocation.
 - (b) For chemicals and refineries, the tiered approaches give different results due to the different thresholds: the EC IA (where these are in the middle risk tier) is the most stringent while the UK/FR proposal is the most generous scenario (where these are classified at high risk).
 - (c) On the other hand, for sectors at lower risk of carbon leakage the EC's binary scenario is the most generous for:
 - Cement and paper & pulp which lie in the middle risk tier in both tiered proposals;
 - Hollow glass, which lies in the low risk tier in both tiered proposals;
 - Lime & plaster and ceramic tiles & flags, which are medium risk in the UK/FR and low risk in the EC IA classification; and
 - Ceramic bricks & construction products, which is below the low carbon risk threshold under both tiered proposals

- 5 Broadly speaking, the tiering approaches are more effective in supporting the sectors most at risk of carbon leakage than the binary approach. Of the two tiering approaches, the UK/FR Phase IV proposal seems better at targeting sectors at high risk of carbon leakage, while the EC IA proposal is more generous to sectors at middle or low risk.
- 6 Assuming full carry-over of unused allowances to subsequent years (banking), calculations give an indication of the level of potential free allowances and how long they would last over time – overall impacts are different across sectors:
 - (a) For refineries and the hollow glass sector, free allowances could have run out in 2016 and a 4.6% and 5.5% deficit relative to 2008-2030 emissions is projected by the end of Phase III respectively;
 - (b) For paper & pulp the historical over-allocation could have run out in 2021 or 2022, depending on the scenario;
 - (c) For the steel the historical over-allocation could cover projected deficit in all Phase IV scenarios;
 - (d) For chemicals, cement and the lime & plaster sector, over-allocation could cover the projected deficit until almost the end of Phase IV; and
 - (e) For ceramic bricks & construction products, over-allocation could last through Phase IV, or run out in 2025, depending on the scenario.

3.2 Research objectives

This task aims to assess the allocation of free EU ETS allowances to UK industry, both historically and into the future. The historical emissions and free allocation of permits were compared (on a sector by sector basis) and extrapolated based on future policy proposals for Phase IV of the ETS to estimate the historical and future allocation of ETS permits to industry. The value of this over- (or under-) allocation was also assessed to understand the financial magnitude of the policy impact relative to the size of the sector.

3.3 How the research was carried out

Information was collated that describes verified emissions and emissions allowances in the EU ETS from all UK-based sites for Phase I (2005-2007), Phase II (2008-2012) and Phase III up to 2016. Data from the BEIS website and the European Union Transactions Log (EUTL) were used. The difference between verified emissions and allowances were calculated for each installation to identify over- (or under-) allocation in each Phase. Historical ETS prices were used to calculate the potential value of this over- (or under-) allocation.

To estimate future surpluses of allowances, emissions and annual allowances were projected forward for the rest of Phase III until 2020 and Phase IV until 2030. Emissions were assumed to be constant from 2016 onwards. For Phase III (2017-2020) allocation, projections were taken from the EUTL data.

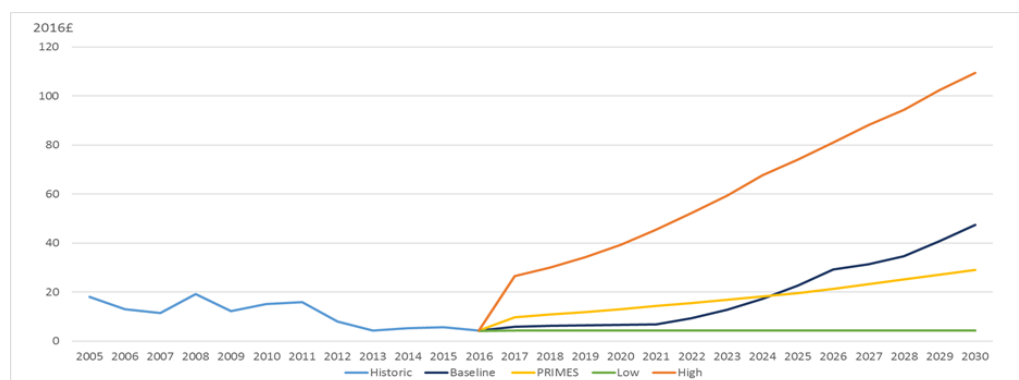
For the Phase IV (2021-2030) allocation projection, three scenarios were developed to reflect different proposed approaches to free allocation for the sectors deemed at risk of carbon leakage. The section 'Phase IV policy proposals' below details the scenarios and assumptions made.

The difference of projected emissions and annual allowances were calculated to identify over- (or under-) allocation going forward, for Phase III (2016-2020) and Phase IV (2021-2030).

Four different ETS prices were used to calculate values, see also Figure 3.1 Carbon Price Scenarios:

- 1 Baseline: "central carbon price scenario" from DECC/BEIS assumptions (2015)
- 2 Primes: based on the EC's PRIMES reference scenario 2016
- 3 Low: assuming constant ETS price after 2016
- 4 High: "High carbon price scenario" from DECC/BEIS assumptions (2015)

Figure 3.1 Carbon Price Scenarios



Approximate GVA at basic prices were sourced from the 2016 UK Office of National Statistics' Annual Business Survey (ONS ABS) report²⁵. Carbon leakage indicator values (see Box 1) were sourced from the joint non-paper by France and the United Kingdom on the Implementation of Tiered Free Allocation in Phase IV of EU ETS²⁶.

²⁵ See 'A Note on GVA Analysis' in the appendix for details.

²⁶ [Implementation of Tiered Free Allocation in Phase IV of EU ETS](#)

Table 3-1 Carbon leakage indicator

Criteria to assess carbon leakage (based on the Commission Decision No 2010/2/EU of 24 December 2009) has changed from Phase III to Phase IV	
<p>In Phase III, according to the ETS Directive (Article 10a), a sector or sub-sector is deemed to be exposed to a significant risk of carbon leakage if:</p> <ul style="list-style-type: none"> • Direct and indirect costs increase production costs by at least 5% of GVA and trade intensity is $\geq 10\%$ <p>or</p> <ul style="list-style-type: none"> • Direct and indirect costs increase production costs by at least 30% <p>or</p> <ul style="list-style-type: none"> • Trade intensity $> 30\%$ 	<p>In Phase IV, trade intensity and emissions intensity are multiplied to calculate the carbon leakage indicator.</p> <ul style="list-style-type: none"> • In the EC Proposal a sector is at risk of carbon leakage if this indicator is above or equal to a 0.2 threshold. Those above 0.12 could also be included based on a qualitative assessment. • In other proposals four leakage risk categories are defined (high-, medium-, low-, or no-risk) with corresponding compensation levels (100%, 80%, 60% and 30%, respectively), depending on thresholds set. E.g. if this indicator is ≥ 2.5, the sector is considered to be at high risk and receives 100% free allocation. see the next section that details this.
<p>The trade intensity indicator is defined as the ratio between the total value of exports to non-EU countries plus the value of imports from non-EU countries, and the total EU market size.</p>	<p>The carbon emissions intensity criterion is defined as a share of the GVA of a sector, specifically: $TC_i = [(D_i \times AF + I_i) \times P] / GVA_i$, whereby the carbon intensity of sector i is a function of its direct CO₂ emissions (D_i), the auctioning factor (AF), the indirect emissions from electricity consumption (I_i), the carbon price (P) and the sector GVA.</p>

Table 3-2 lists manufacturing sectors covered in this analysis, which were chosen based on their competitiveness risks in the EU ETS (measured by their carbon leakage indicator).

Table 3-2 Manufacturing sectors covered in the analysis

NACE	Sectors included in this analysis	Carbon Leakage Indicator ²⁷
17	Pulp	1.68
	Paper	1.17
19.2	Refineries	1.98
20.1, 20.3, 20.4, 20.5	Chemicals – fertilizers, inorganic & organic	>2
23.13	Non-metallic minerals – hollow glass	0.78
23.31	Non-metallic minerals – ceramic tiles & flags	0.93
23.32	Non-metallic minerals – bricks & construction products	0.17
23.51 & 23.52	Non-metallic minerals – cement	1.27
	Non-metallic minerals – lime & plaster	0.97
24.1	Steel	>2.5

The chemicals sector is quite diverse in terms of its carbon leakage indicators. For simplicity of calculation, 20.2 (fertilisers) has been assigned to the same tier in the Phase IV scenarios as the other chemical installations. Its carbon leakage indicator is high (>4) but there are only two installations open in the UK.

Again, for simplicity of calculation, paper and pulp installations have been treated as having a single carbon leakage factor, which is less than 1.6 because about 14% of the NACE's 17 installations are pulp.

From the non-metallic minerals sector, refractory products (23.2, carbon leakage indicator 0.87) were excluded as there is only one open installation. Hollow glass (23.13), cement (23.51) and lime & plaster (23.52) were included as their allocation would be different under the Phase IV scenarios. Ceramic bricks and construction products (23.32) has been included to enrich the analysis with a sector with a low carbon leakage indicator.

3.4 EU ETS Phases I-III (2005-2020)

Within the context of the UNFCCC, the EU committed to reducing its greenhouse gas emissions and launched its emissions trading scheme, the EU ETS on 1 January 2005. The framework for the EU ETS has been defined by Directive 2003/87/EC (European Commission, 2003). The EU ETS limits

²⁷ (2016), 'Implementation of Tiered Free Allocation in Phase IV of EU ETS: a joint non-paper by France and the United Kingdom' ([link](#)) Note that emissions and trade intensity values are not provided individually.

emissions from more than 11,000 heavy energy-using installations (power stations and industrial plants) as well as airlines operating between 31 European countries and covers around 45% of the EU's greenhouse gas emissions.

Phase I (2005-2007) was a period for evaluating the feasibility of the system and its effect on emissions. This so-called pilot phase was an experiment to test the functionality of the scheme rather than a tool to deliver substantial emissions reductions. Phase I covered only CO₂ emissions from power generators and energy-intensive industries and almost all allowances were distributed for free. The EU ETS covered 25 EU countries from the start and Romania and Bulgaria joined in 2007.

Phase 2 (2008-2012), which coincides with the first commitment period of the Kyoto Protocol) had a lower cap on allowances (some 6.5% lower compared to 2005) and free allocation was around 90%, with several countries holding auctions. Three new countries joined – Iceland, Liechtenstein and Norway and NO₂ emissions were also included by several countries (including the UK).

In Phases I and II both cap-setting and allocation processes were highly decentralized at national level through national allocation plans (NAPs). Phase I NAPs were based on estimates by governments and Phase II NAPs were based on verified emissions data from Phase I. From 2012, EU ETS operations were centralised into a single Union registry and the European Union Transaction Log (EUTL) replaced the Community Independent Transaction Log (CITL).

Phase I turned out to be over-allocated and with supply exceeding demand the price of allowances fell to zero in 2007. In Phase II the 2008 economic crisis caused a reduction production and thus emissions that led to a large surplus of allowances, causing low prices.

From **Phase III (2013-2020)** a single, EU-wide cap is determined instead of aggregating national plans. While the five-year cap was flat during Phase II, the Phase III cap decreases each year by a linear reduction factor (LRF) of 1.74%. Auctioning is the default method for allocation, and more sectors and gases are included. In sectors other than power generation a transition to auctioning takes place progressively (see Table 3-3 below).

Table 3-3 Free Allocations²⁸

Phase I	Phase II	Phase III
100% free allocation	ca. 90% free allocation	57% auctioned, 43% for free allocation 100% free allocation to sectors at risk of carbon leakage. 80% of 2013 allocation for free, decreasing to 30% by 2020 to other sectors not deemed at risk.

²⁸ Free allocation refers to benchmarked value of allowances in a (sub)sector. Benchmarks reflect the average performance of the 10% most efficient installation in terms of their GHG emissions. [More info.](#)

3.5 Banking

Installations can carry over allowances from a given year to subsequent years, and subsequent phases - this intertemporal trading is called 'banking'.

Phase I allowances could not be banked for use in Phase II, which explains why prices in 2007 fell to zero. Banking could be considered at least a partial explanation when evaluating discrepancies between total free allocations in a given year or phase, and total allowances used in that year; the difference being allocation that was set aside to be used in later years, rather than being sold in the year of surplus.

This observed difference between allocation and allowances used has been the motivation for the debate about 'back-loading' in 2013, as well as for the proposal made in January 2014 to establish a Market Stability Reserve. Both measures reduce the number of allowances available in the near-term while putting the withdrawn allowances back into circulation at a later time. As a short-term measure the Commission postponed the auctioning of 900 million allowances until 2019-2020. The auction volume was reduced by 400 million allowances in 2014, 300 million in 2015 and 200 million in 2016.

Banking is an installation-level decision, therefore whilst sectoral analysis is illustrative, it should be noted that individual firms within a sector could have different results from the whole sector.

3.6 Carbon leakage

Recognising the risk of firms in energy-intensive industries moving production to regions outside the EU with lighter emission reduction regimes (so-called "carbon leakage") free allowances are granted to some companies with installations in the EU ETS.

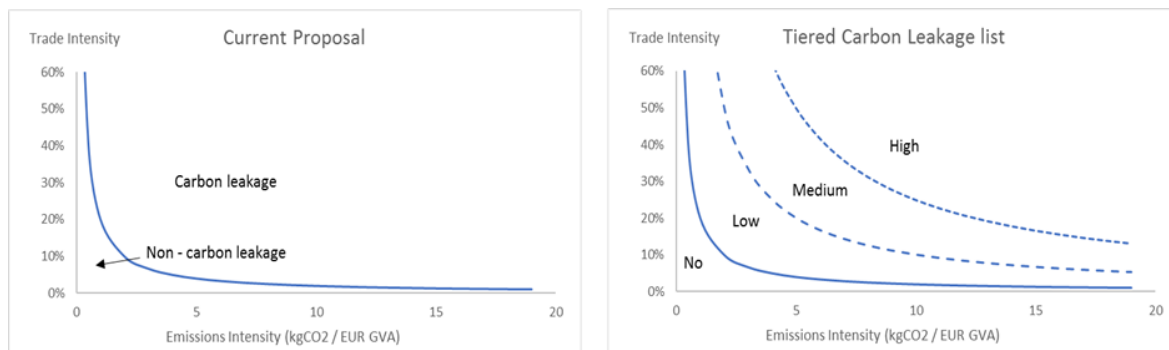
A binary approach is used during Phase III (see Table 3-2) and Phase IV proposals are currently being discussed (see Table 3-4). The next section discusses carbon leakage treatment from 2020.

3.7 Phase IV policy proposals

From 2020, carbon leakage risk will be assessed differently by multiplying two indicators: trade intensity and emissions intensity (see table 1), to determine a single carbon leakage indicator. Depending on the value of the carbon leakage indicator, there are various proposals on how to treat sectors considered at risk of carbon leakage. On 15 December 2016, both the ITRE and ENVI committees voted for the continuation of the current binary approach, despite earlier drafts proposing a tiered approach (see table 3). This decision is undergoing the ordinary legislative procedure, whereby both the European Parliament and the Council need to agree on the final legislation, so the decision is still uncertain, hence our analysis looks at both possibilities.

- 1 Binary approach to carbon leakage, based on the interpretation of the official European Commission proposal²⁹. In this case if the carbon leakage indicator is above the proposed threshold value of 0.2, the sector is considered to be at risk of carbon leakage and receives 100% free allocation against their benchmark; other sectors receive 30% in 2021 declining to zero in 2027.
- 2 Tiered approach to carbon leakage, based on the EC Impact Assessment³⁰ and the UK-France proposal this approach could ensure those sectors at greatest risk of carbon leakage receive the greatest share of free allocation against their benchmarks as possible, whilst providing adequate coverage to sectors at relatively lower risk of carbon leakage. Four leakage risk categories are defined (high-, medium-, low-, or no-risk) with corresponding compensation levels, depending on the thresholds set.

Figure 3.2 Binary vs tiered approach to carbon leakage



Source: Adapted from Ecofys (2016): Feasibility check on correction factor and benchmark updates in EU ETS phase IV.

The benchmark reductions used in the Phase IV analysis were the same across each proposal; two updates are applied, for the periods 2021-2025 and 2026-2030. The benchmark reduction is a 0.5% annual reduction,³¹ from 2008 to the middle year of the relevant period; that is a 7.5% and 10% reduction respectively. This 0.5% figure is the most conservative benchmark reduction proposed by the EC.

A cross-sectoral correction factor (CSCF) was required for the EC binary proposal only. The CSCF is triggered from 2024, under the 0.5% benchmark reduction assumption, see Table 3-4.

See Table 3-5 and Table 3-6 for thresholds and free allocations against benchmark.

²⁹ European Commission (2015), 'Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments', [link](#).

³⁰ European Commission (2015), 'Impact Assessment', [link](#)

³¹ Note that the reduction is not compounded.

Table 3-4 Treatment of carbon leakage in Phase III vs. Phase IV proposals³²

	Phase III (2013-2020)	Phase IV - EC proposal	Phase IV - UK/FR & EC IA proposals
LRF	Linear Reduction Factor 1.74%	Linear Reduction Factor 2.2%	Linear Reduction Factor 2.2%
CSCF ³³	Cross Sectoral Correction Factor 5.7% (94.3% of preliminary allocation) in 2013 going to 17.6% (82.4% of preliminary allocation) in 2020	Cross Sectoral Correction Factor may need to be introduced during Phase IV, depending on benchmarks set. Under 0.5% benchmark reduction ³⁴ : 2021-2023: 1 2024: 0.97 2025: 0.92 2026: 0.89 2027: 0.86 2028: 0.84 2029: 0.81 2030: 0.78	No Cross Sectoral Correction Factor
Approach to leakage	Binary approach	Binary approach	Tiered approach
Free allocation	100% free allocation to sectors at risk of carbon leakage. 80% of 2013 allocation for free, decreasing to 30% by 2020 to other sectors not deemed at risk	100% free allocation to sectors at risk of carbon leakage. 30% to other sectors not deemed at risk, declining to 0% free allocation by 2027	'Tiering' of sectors at varying risk of carbon leakage with varying degrees of free allocation (see tables 3. and 4. below) 30% to other sectors not deemed at risk, declining to 0% free allocation by 2027
Criteria to assess leakage	<ul style="list-style-type: none"> • Direct and indirect costs increase production costs by at least 5% of GVA and trade intensity is $\geq 10\%$ or • Direct and indirect costs increase production costs by at least 30% or 	Trade intensity and emissions intensity are multiplied to calculate the carbon leakage indicator. A sector is at risk of carbon leakage, if this indicator is ≥ 0.2 threshold. Those above 0.12 could also be included based on a qualitative assessment.	Trade intensity and emissions intensity are multiplied to calculate the carbon leakage indicator. Four leakage risk categories are defined (high-, medium-, low-, or no-risk) with corresponding compensation levels (100%, 80%, 60% and 30%, respectively), depending on thresholds set.

³² See https://ec.europa.eu/clima/policies/ets_en, and footnotes 3, 5, & 6

³³ Estimating the CSCF under different scenarios is beyond the scope of this analysis, given that it requires calculations using all installations. Details of CSCF estimates were kindly provided by ECOFYS.

³⁴ CSCF estimates for the EC binary proposal are taken from the report 'Feasibility check on correction factor and benchmark updates in EU ETS phase IV' (ECOFYS 2016), Figure 5 in Scenario 1. The scenario is comparable but not identical to that modelled in this analysis: the ECOFYS scenario is not a flat rate reduction across all sectors. See report for full assumptions and description.

	Phase III (2013-2020)	Phase IV - EC proposal	Phase IV - UK/FR & EC IA proposals
	<ul style="list-style-type: none"> Trade intensity > 30% 		E.g. if this indicator is ≥ 2.5 , the sector is considered to be at high risk, and receives 100% free allocation.
Sectors at risk	167 sectors account for 96% of free allocations	~ 50 sectors, account for 94% of free allocations	14 sectors in the highest carbon leakage tier, account for over 80% of free allocations
Benchmarks		Benchmarks updated twice during phase IV: all benchmarks reduced by 7.5% between 2021 and 2025, and 10% between 2026 and 2030, on 2008 levels (i.e. 0.5% flat rate per annum to the middle of the benchmark period). ³⁵	Benchmarks updated twice during phase IV: all benchmarks reduced by 7.5% between 2021 and 2025, and 10% between 2026 and 2030, on 2008 levels (i.e. 0.5% per annum), reflecting conservative emissions reduction potential.

Table 3-5 Scenario from the European Commission's Impact Assessment³⁶

Tiers	Carbon leakage indicator	Sectors included in this analysis	Allocation against benchmark
High Risk	≥ 2.5	Steel (24.1)	100%
Medium Risk	≥ 1 to 2.5	Pulp & paper (17), Refinery (19.2) Chemicals (20.1, 20.2, 20.3, 20.4, 20.5) Non-metallic minerals (23.51 cement)	80%
Low Risk	≥ 0.2 to 1	Non-metallic minerals (23.13 hollow glass, 23.31 ceramic tiles & flags, 23.52 lime & plaster)	60%
No Risk	0 to 0.2	Non-metallic minerals (23.32 ceramic bricks and construction products)	30% in 2021 to 0% in 2027

³⁵ The EC proposal itself gives provision for different benchmark reductions across industries. The default would be 1%/yr. For industries with lower potential for reducing emissions, the benchmarks would be reduced by 0.5%/yr. And for industries with more potential by 1.5%/yr.

³⁶ http://europeanmemoranda.cabinetoffice.gov.uk/files/2016/01/EU_ETS_Phase_IV_Tiering_Non-Paper_20151022.pdf

Table 3-6 Balanced High Risk Tier Scenario from the UK/FR proposal³⁷

Tiers	Carbon leakage indicator	Sectors included in this analysis	Allocation against benchmark
High Risk	≥1.6	Refinery (19.2) Chemicals (20.1, 20.2 20.3, 20.4, 20.5) Steel (24.1)	100%
Medium Risk	≥0.9 to 1.6	Non-metallic minerals (23.51 cement, 23.31 ceramic tiles & flags, 23.52 lime & plaster) Pulp & paper (17)	75%
Low Risk	≥0.2 to 0.9	Non-metallic minerals (23.13 hollow glass)	50%
No Risk	0 to 0.2	Non-metallic minerals (23.32 ceramic bricks and construction products)	30% in 2021 to 0% in 2027

Cross-sectoral findings are presented below. Sectoral findings are in appendices. Phase IV calculations take the three policy scenarios about the treatment of carbon leakage into account and compare results for the binary approach and the two tiered approaches.

³⁷ <http://carbon-pulse.com/wp-content/uploads/2016/03/Implementation-of-Tiered-Free-Allocation-in-Phase-IV-of-EU-ETS-a-joint-n....pdf>

3.8 Cross Sectoral Findings

In Phase I (2005-2007), allocation was almost in line with verified emissions for most sectors. Allocation entirely covered emissions for six sectors out of the nine included in our analysis: steel, refineries chemicals, paper & pulp, ceramic bricks & construction products, and lime & plaster. Two sectors, hollow glass and cement, were under-allocated; by 29% and 7% of Phase I emissions respectively.³⁸

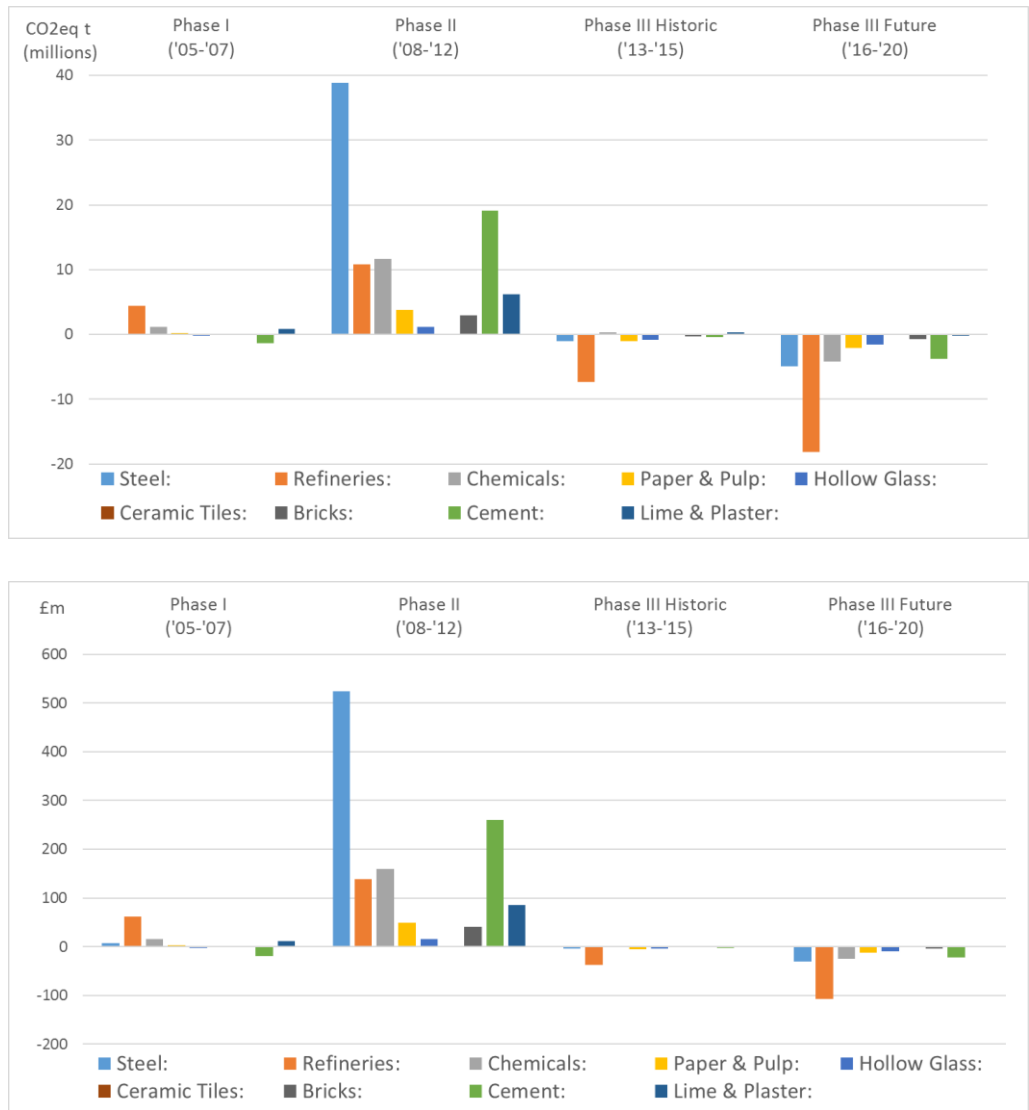
All sectors were over-allocated in Phase II (2008-2012), to a different degree. The steel sector's overallocation had a value of over £500m, for cement £260m, for chemicals £159m, refineries £139m and lime & plaster's overallocation amounted to £89m - based on carbon prices at that time corrected to 2016 £'s.

Phase III (2013-2020) allocation closely matched verified emissions until 2016 for three sectors: steel, chemicals, and cement. The refineries sector, paper & pulp, hollow glass, ceramic tiles and flags, and ceramic bricks were under-allocated by 18%, 19%, 27%, 18%, & 25% of emissions until 2016 respectively. In future, all sectors will receive fewer permits than their projected emissions (under assumptions of constant production and emissions intensity).³⁹ In absolute terms, this will mostly affect refineries and steel – over £100m extra cost to cover permits.

³⁸ There are no installations in Phase I in ceramic tiles.

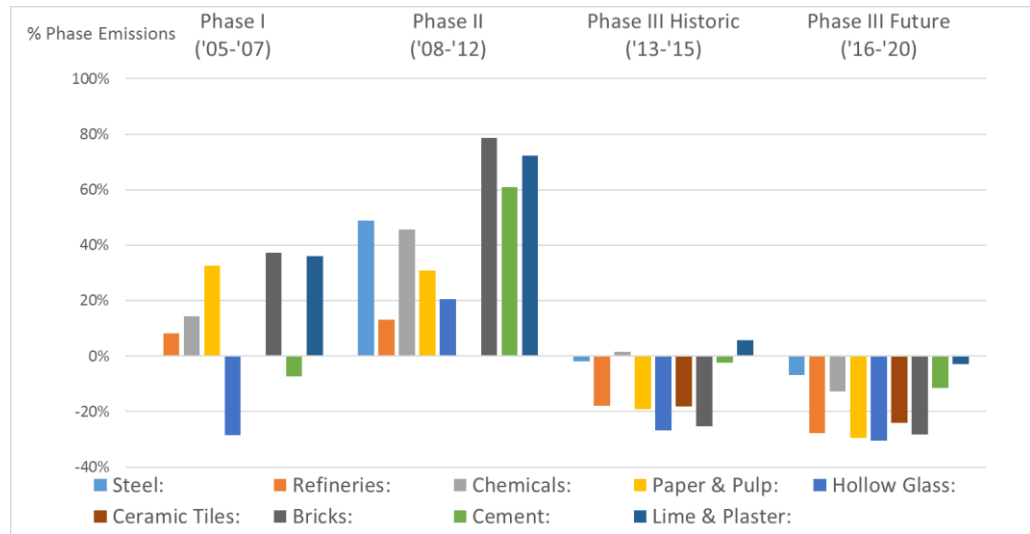
³⁹ The main analysis assumes zero banking, that any over-allocation is sold in the given year, at the market price. A complementary analysis (see Figure 3.8 Cumulative overallocation by 2030, assuming full banking of surplus allowances, expressed as a share of total (estimated) emissions across Phases II – IV Figure 3.8 and in the Sectoral Findings) examines the case of full banking of over-allocation.

Figure 3.3 Extent and value of over or under-allocation in the sectors included in the analysis, 2005-2020



Source: Cambridge Econometrics.

Figure 3.4 Difference between free allocation and emissions, as a percentage of sectoral emissions, 2005-2020



Source: Cambridge Econometrics.

In Phase IV (2021-2030) – under the assumptions of this analysis⁴⁰ – all sectors would be under-allocated. The extent of this deficit depends on the proposal chosen, depending on the classification of carbon leakage tiers and the benchmarks used for free allocation. The refineries and cement sectors would be most under-allocated. For the steel sector the EC’s binary approach is significantly more detrimental than the tiered approaches. For chemicals, the UK/FR tiered proposal would be least detrimental; while for the other sectors the extent of the difference is not significant compared to combined GVA.

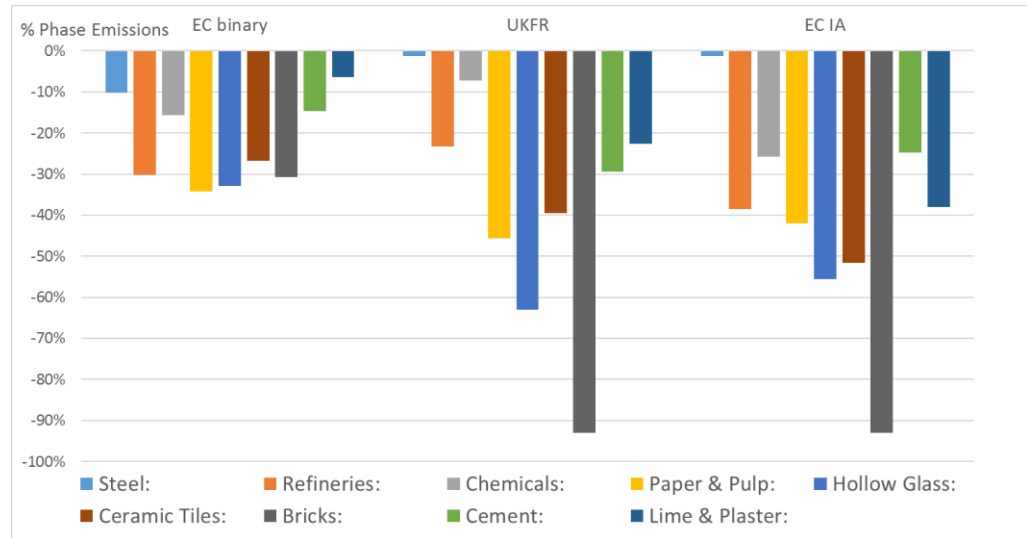
⁴⁰ Constant production and emissions intensity.

Figure 3.5 Extent and value of under-allocation in the sectors included in the analysis, 2020-2030



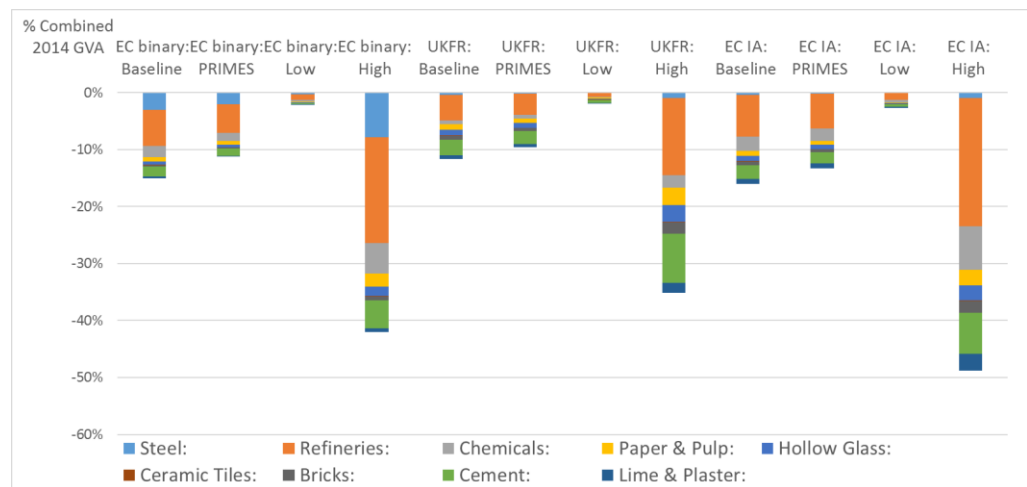
Source: Cambridge Econometrics.

Figure 3.6 Difference between free allocation and estimated emissions, as a percentage of sectoral emissions, 2020-2030



Source: Cambridge Econometrics.

Figure 3.7 Value of under-allocation compared to combined annual GVA, 2020-2030



Source: Cambridge Econometrics.

The tiered proposals, in general, shift the cost of permit under-allocation from sectors at greater risk of carbon leakage, to those at lesser risk. Therefore, the tiered approaches target the limited allowance of free permit allocation. Through reducing free allocation to those sectors facing lower risk of carbon leakage, the tiered approaches avoid the CSCF triggered in the binary approach; a blunt tool that is non-discriminatory with regards to carbon leakage.

The UK/FR proposal is more generous for sectors most at risk of carbon leakage compared to the EC IA proposal; the under-allocation on steel, refineries, and chemicals is lower in the UK/FR proposal than under the EC binary approach. This is not the case for the EC IA proposal, where the scale

of under-allocation of permits is higher in the tiered approach compared to the binary for both chemicals and refineries. This highlights the fact that the generosity of allowance allocation in the tiered approach to at risk sectors depends entirely on how well the tier thresholds are set.

The thresholds for classification into risk tiers differ between the UK/FR proposal and the EC IA proposal. A lower carbon leakage value for the high-risk tier threshold in the UK/FR proposal increases the number of sectors which receive 100% of benchmark allocation; this is 'payed for' by allocating a lower percentage of benchmark allocation to the medium and low risk tiers. The thresholds are also set such that less than 1% of the free allocation allowance is unallocated, compared with approximately 4% under the EC IA thresholds. Therefore, the UK/FR proposal would allocate more free allocation to the higher risk sectors.

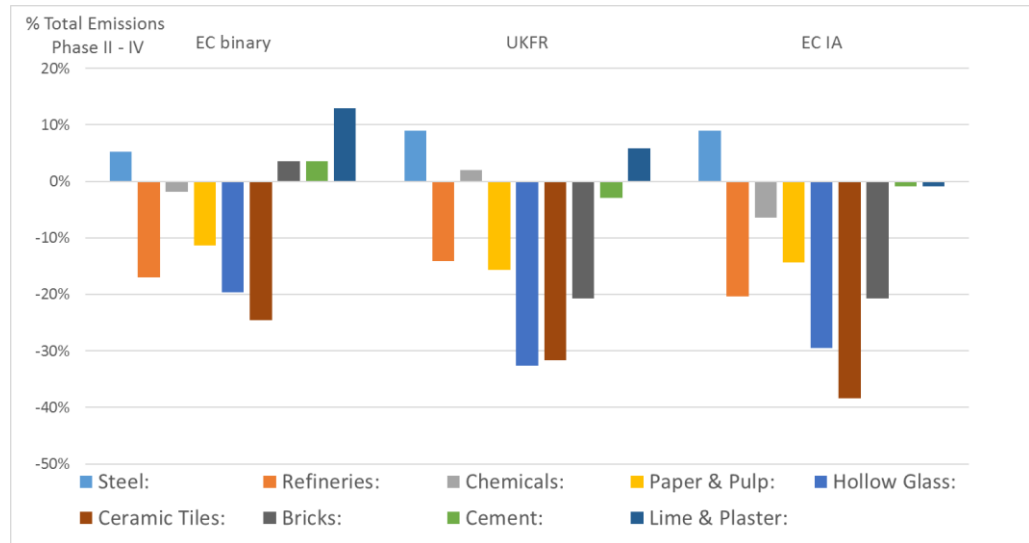
Relative to an estimated annual combined GVA of the sectors studied⁴¹, under the baseline carbon price scenario, the value of under-allocation is below 20% under each Phase IV proposal. Analysis at the sectoral level, however, shows that the potential magnitude of the cost of permits is significant and that this magnitude differs greatly across Phase IV proposals and sectors.

Allowance banking should also be considered when analysing the observed under/over-allocation in the EU ETS. It is not part of this task to quantify to what extent unused allowances accumulated during Phase II and are used in Phase III/IV surrenders. However, Figure 3.8 gives an indication that, potentially, the stock of over-allocation from early phases could have persisted throughout Phase IV. The sectoral analysis in the appendix provides more detail of the time dimension of how this surplus could be used (if available to those sectors).⁴²

⁴¹ See 'A Note on GVA Analysis' in the appendix.

⁴² Whilst sectoral analysis provides informative results, it should be noted that the experience of individual installations within a given sector may be very different: relative over- and under- allocation varies within a sector, and one installation cannot use another's surplus; and banking, which also affects the sectoral analysis, is an installation-level decision.

Figure 3.8 Cumulative overallocation by 2030, assuming full banking of surplus allowances, expressed as a share of total (estimated) emissions across Phases II – IV



Source: Cambridge Econometrics.

Assuming full carry-over of unused allowances to subsequent years, the overall impacts are markedly different. Some sectors’ past overallocation covers their future projected deficits, some would still have a surplus, some would be more or less at zero by the end of Phase IV. Refineries and the hollow glass sector would be most affected by a cumulative deficit of allowances.

4 Sector case studies

4.1 Introduction

As part of this study, we undertook three detailed case studies to look at the underlying trends in three energy-intensive industries that have contracted over 1990-2016 to understand the cause of the contraction and the role of climate change policies in the contraction:

- Aluminium
- Cement
- Steel

The summaries for each industry are presented below and the full case studies are presented in the appendices.

4.2 Aluminium

The aluminium sector covers a range of economic activities, though economic statistics often aggregate these activities together.

Firstly, there is the production of unwrought aluminium and aluminium alloys. This can be achieved in two ways: primary production of aluminium from alumina (primary production) and secondary production of aluminium from recycled scrap aluminium.

- Primary aluminium production is a particularly electro-intensive process, with energy accounting for 69% of conversion costs, compared to 22% for secondary production⁴³. Primary aluminium production occurs in smelters, and tends to be dominated by large firms.
- Secondary aluminium production tends to be spread across a higher number of smaller plants, operated by a larger number of firms.

The aluminium sector also includes downstream aluminium production. This is the production of semi-manufactured and finished aluminium products, primarily from unwrought aluminium ingots.

The three major types of downstream aluminium products are rolled aluminium products, extruded aluminium products and aluminium castings. Downstream aluminium production also includes production of wire products, powder and slugs.

Downstream producers tend not to be vertically integrated with primary and secondary producers, operating separate plants such as rolling mills, extrusion plants and casting foundries.

Key conclusions

The key conclusions for aluminium are as follows:

⁴³ https://ec.europa.eu/growth/tools-databases/eip-raw-materials/en/system/files/ged/82%20fn97624_nfm_final_report_5_april_en.pdf

- The real value of production of the UK aluminium sector contracted by nearly 50% over 1996-2015.
- Global demand for aluminium has more than tripled since 1990, but was significantly weakened in Europe by the 2008 recession.
- Falling domestic demand in the UK sector, including falling demand from the downstream production industry, together with falling demand in the EU, drove the overall sector contraction. In particular, the UK transport equipment sector and the construction sector contracted sharply during the recession, weakening demand for aluminium. In addition, increasingly high electricity costs led to the shift from primary aluminium production to secondary aluminium production in the UK.
- Primary production capacity in the UK plummeted following the closure of the Anglesey smelter in 2009, having failed to secure a new long-term electricity contract, and the closure of the Lynemouth smelter in 2012, attributed to rising energy costs and increasing global competition. Indeed, both closures followed a sharp rise in electricity costs in the UK over 2004-09, amid weak UK and EU demand for aluminium during the economic downturn. In contrast France and Germany, which faced lower industrial electricity costs, have kept stronger levels of primary production, though they have seen closures of smaller, less efficient smelters.
- Secondary production in the UK fell overall over 1997-2011, though by a lesser extent than primary production. Secondary production first fell over 1999-2002, linked to the high cost of scrap metal in these years, and falling demand from the domestic downstream production industry. Secondary production contracted further over 2007 amid falling demand along the downstream supply chain in the EU, driven by the financial crisis and its aftermath. However, secondary production increased in recent years after the collapse of primary production.
- Downstream aluminium production has also declined significantly in the UK. Plant closures in the early 2000s were linked to a loss of competitiveness due to a strong pound against the euro, and weak demand in the EU. Indeed, semi-manufactured products were increasingly imported to the UK from the 2000s onward, as domestic demand stayed firm from key downstream users such as the transport equipment sector and the construction sector. UK downstream production fell further during the economic downturn, this time driven by falling demand from downstream users, both in the UK and the EU.
- Labour productivity grew faster in the UK aluminium sector than in France and Germany over 1998-2014. Furthermore, unit labour costs in the UK aluminium production sub-sector were always lower than in Germany over the period of study, and fell below France after the 2008/09 recession.

- The UK aluminium sector faced significantly higher energy costs than in France and Germany in most years of this study. In the UK, aluminium production sub-sector, energy costs grew rapidly over 2001-08.
- The increasingly high unit energy costs in the UK aluminium sector leading up to 2009 reflect a sharp surge in industrial electricity prices over 2004-09, which outpaced the price increases seen in France and Germany. This was driven mainly by rising gas prices pushing up wholesale prices. The UK energy supply is highly dependent on gas – more so than its European competitors.
- The aluminium sector was not directly affected by the ETS, as it was not included in the scheme until 2013, and was granted free allowances upon its inclusion. However, a range of EU and UK climate change policies have raised UK electricity prices, mainly the ETS, the Climate Change Levy (CCL), the Renewables Obligation (RO), and the Carbon Price Floor (CPF). Primary aluminium producers are particularly exposed to electricity price increases, due to the high electro-intensity of the primary aluminium production process. Industry has argued that UK climate change policy was particularly stringent compared to those faced by European competitors.
- Climate change policies have increased costs for the sector, though measures such as compensation, exemptions, tax incentives and the awarding of EU ETS free allowances are limited the impact. However, the UK was slower to provide relief to industry through its Energy-Intensive Industries (EII) package than other EU countries.
- Results presented in chapter two of this report show that UK industrial electricity prices are currently high relative to EU competitors mainly due to higher wholesale prices (driven by the gas prices) and network costs. Climate change policies have a far smaller impact, though some of these costs will have been higher before the full implementation of the EII package in 2016.
- Discounting the impacts of policy on electricity prices, the EU is still a less attractive location for primary aluminium investment, due to the higher cost of energy in the region. There is a growing trend toward secondary production in Europe, and the UK is part of this trend, having seen increased production and investment in recent years.
- Recent investments have also been made in UK downstream production, driven by strong demand from the UK transport equipment sector. However, the UK and indeed Europe, face growing competition from China in semi-manufactured products
- Primary aluminium production, represented by the Lochaber smelter, seems to have been secured in the short term, having recently been acquired by the GFG alliance

- The share of carbon costs in overall electricity prices to aluminium producers (accounting for compensations and exemptions), is forecast to increase by 1.1 percentage points up 2030, while total electricity prices for aluminium producers are forecast to increase by around 53%. Though other EU countries will face similar if not larger increases in carbon costs, it is clear that energy efficiency is key to the UK sector's future competitiveness, particularly in the face of increasing competition from outside the EU.

4.3 Cement

This section summarises the case study findings on the extent to which climate change policies have affected the competitiveness of the UK cement industry. It analyses indicators on output, demand, investment, trade, energy and labour costs to determine the drivers of sectoral performance. The UK cement sector is compared against sectors in France and Germany.

Key conclusions The key conclusions for cement are as follows:

- Global cement production grew from 1.1bn metric tonnes in 1990 to 4.1bn metric tonnes in 2014. In the UK, cement production was stable over 1995-2007, in line with domestic demand. Variations in turnover and value added reflected fluctuations in prices. However, demand declined markedly after the 2008-09 recession. Contraction in UK construction activity has led to a fall in domestic demand of nearly 40% since 2008. In response, UK production of Portland cement contracted from 12.5m metric tonnes in 2007 to 9.3m metric tonnes in 2014.
- Investment as a proportion of production in the UK cement sector picked up a little over 2002-07, driven by strong demand from the construction industry as construction of all types of properties boomed. The collapse of the property boom and subsequent fall in demand from construction led to investment collapsing considerably after 2007 and it has not yet recovered. Investment in France and Germany after 2007 contracted less than in the UK. The operating environment and conditions for the UK cement sector have not been helped by other factors discussed below.
- About 60% of the sector's energy needs are met by coal, down from over 80% in 2007, with the rest being met largely by electricity. As such, the cost of energy for the UK cement sector has been influenced by trends in international coal prices. These increased roughly four-fold over 2002-08 and drove up the per unit energy cost in the UK. At the same time, UK industrial electricity prices surged upwards over 2004-09, driven by sharp increases in gas prices. The increase in electricity prices in the UK was greater than in other EU countries because of the UK's dependence on gas in the electricity sector. In France, the per unit energy cost remained low and stable over the period.
- The impact of high or volatile coal prices can be mitigated against through the use of fuels derived from waste, but the UK sector was

initially slow in switching to alternative fuels compared to its counterparts in France and Germany. However, substantial progress has been made by the UK sector since the mid-2000s and in 2015 over 40% of the thermal input was derived from alternative waste materials.⁴⁴

- Prior to 2008, the UK cement sector was characterised by relatively high labour costs (per tonne of output) and relatively low labour productivity (measured as tonnes of cement producer per worker), compared to the cement sector in France and Germany. Thus, it is hard to argue that any lack of competitiveness prior to 2008 was down solely to low carbon policies. Since 2008, the labour cost (per tonne of output) has fallen in the UK and is the lowest among the three countries. At the same time, labour productivity in the sector increased to its highest level since the early-2000s in 2014 and surpassed labour productivity in France.
- Import penetration in the UK increased substantially in recent years. Over 1996-2006, the share of demand met by imports was relatively stable at 8-10% (similar to the rate in France and Germany). However, since 2006 it has risen steadily to around 27%, far higher now than in Germany and France. The share of demand being met by imports has increased because demand has fallen while imports, mostly from within the EU, have stayed flat.
- Climate change policies such as the EU Emissions Trading System (EU ETS), Climate Change Levy (CCL), Carbon Price Support (CPS) and support for low-carbon generation through Renewables Obligations (RO), Feed-in-Tariffs (FiTs) and Contracts for Difference (CfD) increase costs for energy-intensive sectors. However, UK and EU measures such as compensation, exemptions and the awarding of EU ETS free allowances have lowered the cost impact of carbon policies on the UK cement sector.
- As a proportion of the industry electricity price, the 2016 indirect EU ETS carbon cost was 2.2%, 6.7% for Carbon Price Support, 0.6% for Feed-in-Tariffs, 2% for Renewables Obligations and 1.3% for Contracts for Difference.
- Carbon policies have not led to a loss of competitiveness since most UK cement trade is with EU countries which are subject to similar carbon policies, apart from the Carbon Price Support introduced in 2013. The cement sector contends that there has been an impact on competitiveness.
- Over the mid-2000s, the UK cement sector is characterised by relatively high labour costs and relatively low labour productivity. At the

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http://cement.mineralproducts.org/current_issues/climate_change/greenhouse_gas_reduction_strategy/waste_derived_fuels_and_material.php

same time, it was largely dependent on coal for its energy needs, the price of which increased roughly four-fold over 2002-08. The price of electricity, on which is it also dependent, increased sharply because of large rises in the price of gas used in electricity generation. The gross operating rate, a measure of profitability, in the UK cement sector was volatile and in overall decline after 2002. The consolidation observed in the sector over this period was a response to these pressures.

- Additional costs as a result of low-carbon policies and delay or ineligibility in accessing some of the compensation would have weakened the sector's position. However, low-carbon policies were not the primary factor in the sector's decline. The decline in UK cement production over 1990-2016 was driven primarily by the contraction in demand from construction following the global economic crisis over 2007-09, exacerbated by high energy (coal and gas) prices.

4.4 Steel

The steel sector includes a wide range of activities, from production of crude steel, to the manufacture of semi-finished and finished products.

Steel production in the UK uses either the Basic Oxygen Furnace (BOF) or Electric Arc Furnace (EAF) production process. BOF covers the full range of production stages, from coke-making, to iron-making, to steel production in the oxygen furnace. The EAF process uses secondary feedstock in the form of recycled steel scrap as its main input. While both production processes are electro-intensive, the main energy cost to the BOF process is coking coal, while electricity is the primary energy cost of the EAF process.

The steel sector is highly vertically integrated between iron-making and steel making activities, and steel finishing activities. Hence, most steelmaking in the UK takes place in integrated steelworks, which cover many of these activities. Steel in the UK is mainly produced using the BOF route, through which around 83% of crude steel is produced, with the remaining 17% produced in EAF steelworks.

In addition, there are many specialist downstream manufacturing plants in the UK, such as wire plants, rolling mills, tubes mills, and casting foundries.

Key conclusions

The key conclusions for steel are as follows:

- The real value of production in the UK steel sector contracted by around 30% between the late-1990s and 2015, driven in part by a sharp contraction over 2007-09.
- The supply chain has increasingly globalised, evidenced by increasing import penetration and export shares of output.
- Demand has been weak since the recession in the UK, but also in the EU. Falling demand in China has led to a global glut of steel.
- The sector was already declining in the long term before the recession, though a modest recovery in basic steel production occurred over

2000-07. In the earlier years, there were two closures of integrated steelworks in 1992 and 2001, both linked to low profitability driven by, among other things, combinations of weak demand, increasing competition from imports, a strong pound or low global steel prices.

- Since the recession, increased global competition from low-cost producers amid weak demand in the UK and the EU and low steel prices have driven UK closures and plant sales.
- The German steel sector has remained strong, while the French sector contracted by a similar amount as in the UK. However, production output in Germany has been falling since 2012. It appears the relatively early introduction of compensation for climate change policy in Germany has helped support the industry. Compensation in the UK for energy intensive industries was introduced later and the total value of compensation provided has been a lot lower.
- UK electricity prices are higher than European competitors largely due to wholesale and network costs rather than carbon costs. However, this accounts for compensations and exemptions for a range of climate change policies that had not been fully implemented until 2016.
- The industry appears to have suffered from downturns in demand the early-1990s and at the turn of the century, with a strengthening of the pound in the second half of the 1990s impacting adversely on competitiveness. This appears to have been compounded in the 2000s as the pace of globalisation picked up and it shifted to a global supply chain that was increasingly fragmented and specialised.
- Rather than climate change policies, the key factor behind the decline of the UK steel sector was the combination of cheap imports from China, and weak demand in the EU.
- The UK steel sector has been buoyed by recent acquisitions of plants formerly owned by Tata. At the same time, a recovery in EU construction sector demand, and future UK public sector infrastructure contracts look set to boost the outlook for the UK steel sector.
- However, cheap imports from China are set to continue as production in the region remains high, despite weaker demand in China's domestic market.
- In addition, Brexit has cast uncertainty over the sector's future trade position with the EU, and the extent to which it will be protected from cheap imports and have access to export markets.
- Lastly, while carbon costs form a relatively small to modest share of industrial electricity prices, this share is projected to increase up to 2030. Furthermore, total electricity prices for UK steel producers are project to increase by 53% over 2016-2030. Hence, energy efficiency is crucial to the UK sector's future competitiveness.

5 Conclusion

The purpose of this project was to support the Committee on Climate Change (CCC) in its ongoing assessment of the impact of low carbon policies on energy prices and bills, and the competitiveness implications of climate change policies and energy prices on the UK manufacturing sectors.

To do this, the project carried out

- An analysis of electricity prices faced by manufacturing sectors in the UK against prices faced by manufacturing sectors in other key countries. This analysis was extended to develop projections of electricity prices in the UK and competitor countries out to 2020 and 2030.
- An assessment of EU ETS free allowance allocation for on UK firms to date; and an assessment of the likely EU ETS free allowance allocation out to 2030 based on current proposals (and assuming the UK remains within the EU ETS).
- Analyses of trends and developments in three industries (aluminium, cement, steel) that have contracted and are illustrative of the trends and pressures faced by energy-intensive industries, to understand the cause of the contraction and the role of climate change policies in the contraction.

Drawing those discrete tasks together, our key conclusions from the analysis are as follows:

The steel and aluminium sectors have been in long-term decline since the late-1990s. By 2008 production in each sector had declined by around 20% since the late-1990s. Cement production was stable over 1995-2007, in line with domestic demand. However, a major driver of the contractions in the three sectors under study was a sharp fall in demand during the 2008-09 recession, driven by contractions in key customer sectors such as motor vehicles, construction and packaging, as household spending and investment fell sharply. Very quickly, production in each sector fell by 20-30% and since then it has remained flat or fallen further.

The decline in the steel and aluminium sectors prior to 2008 was driven by weak market conditions, particularly at the turn of the century, characterised at various times by weak demand and low global prices. This was compounded by a strong pound, which undermined the competitiveness of exports and facilitated an increase in competition from imports; and, in the case of secondary aluminium production, high prices for scrap metal. The adverse impact of these conditions on profitability forced some plants to close.

Looking at labour productivity and unit labour costs, none of the sectors in the UK stood out as being markedly more competitive than their counterparts in France and Germany before 2008. On both measures, the UK sectors were

typically middling or slightly inferior; although labour productivity in the UK aluminium sector generally grew faster over 1998-2008 than in France and Germany, while in the UK steel sector we see absolute and relative improvements in both measures in the period to 2008. Nonetheless, on these measures, the competitive position of the UK sectors has improved in relation to their French and German counterparts, or at worst moved in line, since 2008. However, this has not come through in production and trade flows. Cheap imports from China and weak EU demand weigh heavily on UK steel and aluminium production. The UK cement sector has suffered from the slow recovery in the level of UK construction activity and strong import competition from the EU.

And neither was the competitiveness of the UK sectors aided by developments in unit energy costs prior to 2008. In each sector, unit energy costs were typically higher and/or grew faster in the UK prior to 2008. By contrast, producers in France typically enjoyed lower and more stable unit energy costs. This is because over the historical period producers in the UK were more reliant on fossil fuels for their energy needs, both directly and indirectly, and the prices of fossil fuels (oil, gas, coal) rose sharply between the early 2000s and 2008, roughly four-fold. This knocked on to industrial electricity prices, with average industrial electricity prices practically trebling over the period. Since 2008, unit energy costs have remained relatively high in the UK steel and aluminium industries. Our analysis shows that UK industrial electricity prices are currently high relative to EU competitors mainly due to higher wholesale prices (driven by the gas prices) and network costs, and that costs associated with climate change policies were small relative to electricity costs.

The historical period is characterised by marked increases in import penetration in each market as domestic producers, with middling labour productivity and unit labour costs and higher unit energy costs, struggled to compete against imports made cheaper by a strong pound. Particularly in steel and aluminium, this appears to have been compounded as the pace of globalisation picked up and the UK industries were restructured away from unprofitable and uncompetitive activities focused on serving primarily the domestic market to more profitable and competitive activities located within a wider supply chain serving the global market. This can be seen in a corresponding increase in the share of domestic output that is exported over the period.

The consequence of the trends outlined above was declining profitability in the steel and aluminium sectors in the late-1990s and early-2000s, with the steel sector recording losses in the early-2000s. A small improvement over 2005-08 aside, the rate of profitability in the steel and aluminium sectors has not returned to the highs seen in the mid-to-late-1990s. Meanwhile, although relatively high, profitability in the cement sector weakened over the 2000s with increased volatility.

The corollary of this has been weak or falling investment in each of the UK sectors, with most investment directed towards maintaining or extending the life of existing capacity rather than adding brand new capacity and technologies. This has served to reinforce the contraction in domestic production and the reliance on imports.

The impact of low carbon policies on energy prices and their role in the decline of the three sectors studies has been negative but relatively small. Under the EU ETS, each sector benefited from the over-allocation of free emissions allowances. For industry as a whole, this helped to offset the indirect costs associated with increased electricity costs.

Beyond the EU ETS, UK-specific climate change policy also contributed to rising electricity prices and the UK government was slow to compensate energy intensive industry for the costs of these climate change policies. Compensation and exemptions for many of these policies (the Climate Change Levy (CCL), the Renewables Obligation (RO), Feed in Tariffs (FiTs), the ETS, the Carbon Price Floor (CPF) and Contracts for Difference (CfD)) were introduced much later than the introduction of the policy, through the Energy Intensive Industries (EII) package. The EII package was introduced by the government in 2011, for implementation in 2013, following pressure from industries facing rising electricity prices. However, most of the package was not implemented until 2016.

Given the continued reliance on fossil fuels in industrial production, it is worth noting that if government assumptions about future fossil fuel prices come to bear, this would have a far greater impact on industrial energy costs than increasing policy costs.

Appendices

Appendix A Projecting Wholesale Electricity Prices

A.1 Basis for estimation

The wholesale electricity price is estimated based on the cost of the marginal fuel in the electricity generation mix (as shown in the merit order curve). For most countries that are included in our analysis, gas is the marginal fuel in the merit order and, therefore, we assume that the Long Run Marginal Cost (LRMC) of gas sets the wholesale electricity price.

In some countries, where there is a high share of coal-fired power generation, the price of coal (which is typically cheaper than gas) is the key determinant in setting the wholesale electricity price. This is the case in China, for example, where coal currently accounts for over 65% of total electricity generation. As shown in Table A.1, by 2030, IEA projections suggest that coal-fired power generation will continue to supply over 50% of electricity in the country and, therefore, we assume that the wholesale electricity price in China will continue to depend on the LRMC of coal in our wholesale electricity price projections.

Table A.1 Share of generation from coal, gas and renewables by country in 2030

	UK	Germany	France	Belgium	Netherlands	Ireland	US	China
Coal	0%	31%	0%	0%	11%	8%	26%	51%
Gas	22%	21%	2%	61%	49%	48%	30%	7%
Renewables	51%	39%	33%	33%	25%	41%	23%	31%

Source: CCC, IEA New Policies Scenario

In Germany's case, high dependence on coal for power generation means that the wholesale electricity prices are predominantly determined by the price of coal⁴⁵. Despite this, as shown in Figure A.1, electricity prices have historically followed a similar trend to wholesales gas prices. In our projections, we assume that the share of gas generation in Germany increases relative to the share of coal generation and, by 2030, we assume that the wholesale electricity price will again be dependent on the LRMC of gas.

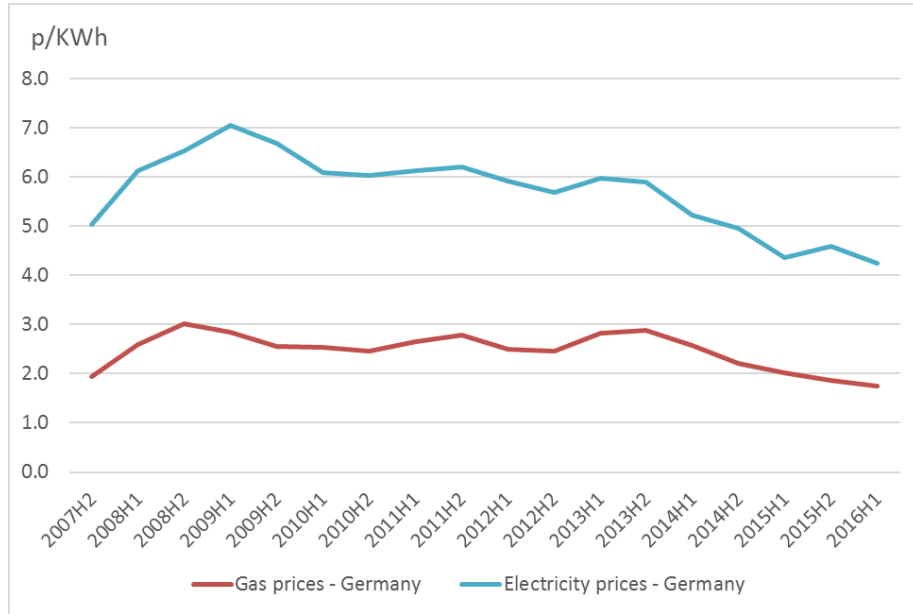
In France, a high share of electricity is generated by nuclear power and, therefore, the LRMC of gas is not as relevant in determining the wholesale electricity price. France imports a relatively high share of electricity (over 6%)⁴⁶

⁴⁵ <https://www.oeko.de/oekodoc/2025/2014-610-en.pdf>

⁴⁶ Commission de regulation de l'energie (2014) 'Functioning of the wholesale electricity, CO2 and natural gas markets'

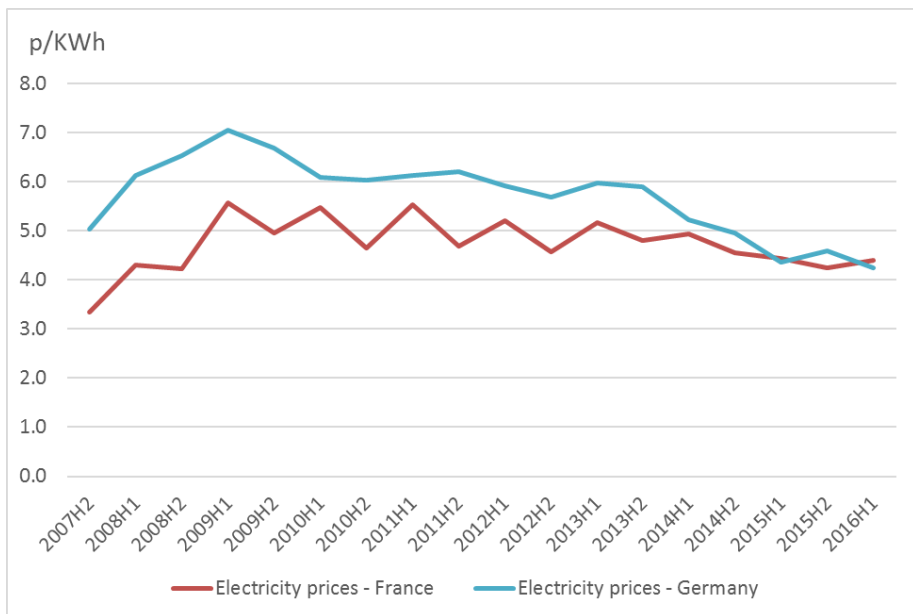
from neighbouring countries and data shows that, over recent years, wholesale electricity prices in France and Germany have begun to converge (see Figure A.2). For wholesale electricity prices in France, we therefore use the wholesale electricity price in Germany as a proxy.

Figure A.1 Electricity and gas prices for large consumers in Germany (excl tax)



Source: Eurostat, BEIS

Figure A.2 Electricity prices for large consumers in France and Germany (excl tax)



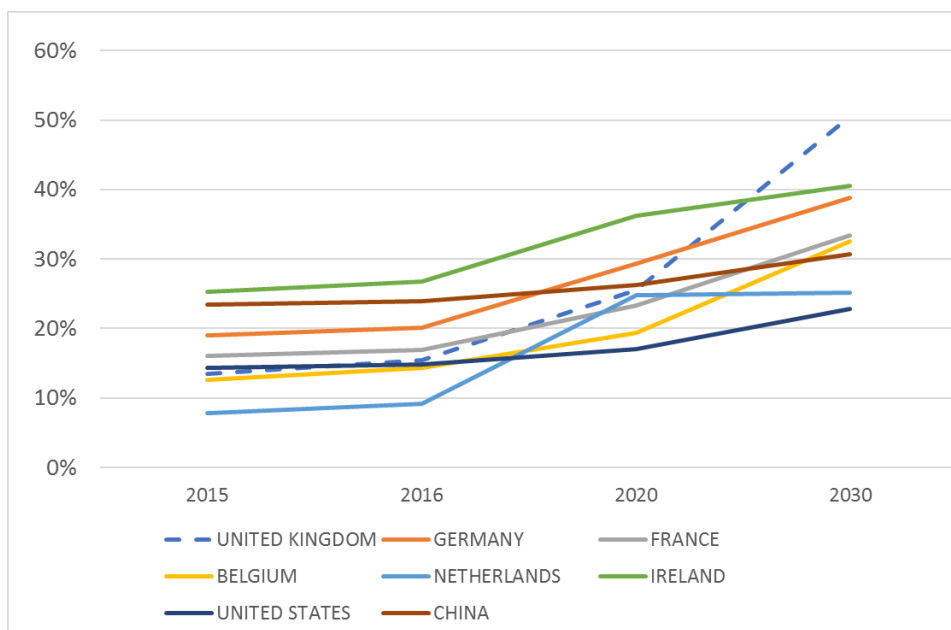
Source: Eurostat, BEIS

A.2 The merit order effect

As renewable electricity generation has close to zero short-run marginal cost, an increase in the share of renewable generation will lead to a general reduction in wholesale electricity prices, as renewable electricity replaces electricity generation from thermal power plants (with higher marginal cost).

In all countries, we assume an increase in the share of renewables in the generation mix over the period to 2030. In the UK, we assume electricity generation from renewable sources grows in line with the CCC's projections and, in all other countries, we assume that the share of renewables in the electricity generation mix grows in line with the IEA New Policies scenario, reflecting climate commitments from the Paris COP (see Figure A.3).

Figure A.3 Assumptions on the share of renewables in the electricity generation mix for each country



Source: IEA, CCC

For our analysis, the merit order effect is estimated using results from the Deane, P. (2015) '*Quantifying the "merit-order" effect in European electricity markets*'.⁴⁷ The paper estimates the average price received by electricity generators in 2030, under given assumptions about the share of renewables in the electricity generation mix. To estimate the scale of the merit order effect in earlier years, we apply the same price adjustment, weighted by the share of zero marginal cost renewables in the generation mix in each year. Thus, the relationship between the share of renewables and the scale of the merit order effect is linearly approximated.

⁴⁷ https://www.ifri.org/sites/default/files/atoms/files/insight_e_european_electricity_market.pdf

A.3 Calibration

Our estimates of the wholesale electricity price, which are based on the LRMC of gas/coal after making an adjustment to account for the merit order effect, do not provide a perfect reflection of the wholesale electricity prices that firms face. To account for differences between the true wholesale electricity price and our estimates of the wholesale electricity price, we calibrated our estimated wholesale electricity costs in 2015 to published data from Eurostat. In developing our projections to 2030, we assumed that this prediction error is maintained and we apply the same fixed calibration factor (in absolute terms) to our future projections.

Appendix B Network costs and data inconsistencies

B.1 Overview

Our estimation of industrial electricity price components in Task 1 relied on transmission and distribution costs data from the Eurostat database. Crucially, this dataset presents disaggregated network costs at the country level reflecting important costs differences among consumers. Different tariffs apply depending on annual electricity consumption patterns and our analysis focused on the following three categories corresponding to Profile 1, 2 and 3:

- 2,000 to 20,000 MWh, representing a small Profile 1 plant
- 20,000 to 70,000 MWh, representing a medium-sized Profile 2 plant
- 70,000 to 150,000 MWh, representing a large Profile 3 industrial customer

Table B.1 shows selected data for the UK, Germany and France. As expected, transmission and distribution tariffs decrease as annual electricity consumption increases.

Table B.1 Eurostat network costs estimates (€ cents/KWh)

	2,000 to 20,000 MWh	20,000 to 70,000 MWh	70,000 to 150,000 MWh
United Kingdom	3.9	3.7	3.5
Germany	2.4	2.1	1.7
France	1.6	1.5	0.9

We compared these figures to transmission and distribution costs previously estimated by ECOFYS (2015)⁴⁸ at the country and sectoral level. As presented in Table B.2, ECOFYS (2015) produced an international comparison of electricity costs of energy-intensive industries decomposed into different cost components, which included network costs. Focusing on four of our selected countries (the UK, France, Germany and the US), the data shows the costs faced by a hypothetical plant with specific characteristics in terms of annual consumption, installed capacity, electricity cost share and full load hours. Table B.2 summarises these characteristics for five plants defined in the ECOFYS report that match our Profile 3 characteristics (Steel EAF, Steel BOF, Aluminium and Paper) and one industry (Industrial Gases) which is less electro-intensive than our Profile 1 category.

⁴⁸ The study is available at the following link:

<http://www.ecofys.com/files/files/ecofys-fraunhoferisi-2015-electricity-costs-of-energy-intensive-industries.pdf>

Table B.2 ECOFYS (2015) network costs estimates (€ cents/KWh)

	Steel EAF	Steel BOF	Aluminium Smelter	Paper	Industrial Gases
United Kingdom	1.8	0.8	1.4	1.6	3.1
Germany	2.0	2.0	0.5	2.0	3.4
Germany with exemptions	1.7	1.7	0.2	1.7	3.4
France	0.6	0.5	0.4	0.5	0.5
USA	2.4	2.4	0.9	2.4	1.4
Annual Consumption (GWh)	572	160	1950	400	1
Installed Capacity (MW)	127	240	230		152
Electricity costs as a share of total production costs	22%	12%			20%
Full Load Hours			8585		6240

B.2 Germany

For Germany, ECOFYS (2015) presents estimates of electricity prices and network costs both with and without exemptions. The report reflects that plants with other 10GWh annual consumption (classified as Profile 2 or 3 in our analysis) benefit from important T&D reductions. However, plants that use less electricity (such as Industrial Gases, in the ECOFYS example) face the entire network tariff without any reduction. In both cases, Eurostat and ECOFYS present comparable network cost estimates of approximately 1.7 € cents/KWh for Profile 3 industries and 3.1 € cents/KWh for Profile 1 plants. Aluminium Smelter is the only exception, where network costs presented in ECOFYS (2015) are considerably lower. With the exception of the Aluminium sector, the Eurostat data does seem to provide an accurate reflection of the transmission and distribution exemptions granted to large electro-intensive industries in the German case.

It is important to note that, as important exemptions apply to plants consuming more than 10GWh per year in Germany, only a portion of firms in the first category (2,000 to 20,000 MWh) will benefit from any exemption. A similar reasoning applies to larger consumption categories as, according to the German law, the number of consumption hours per year determines the percentage reduction in network costs if consuming more than 10GWh of electricity per year.

B.3 UK

Contrary to the German case, Eurostat and ECOFYS T&D costs for the United Kingdom differ substantially. According to ECOFYS (2015), Profile 3 firms in

the UK benefit from network cost reductions. However, Eurostat data do not appear to fully reflect these lower costs. A deeper investigation into ECOFYS (2015) data sources reveals how the specific calculation method could represent the main reason behind this dissimilarity. The reason for the difference between Eurostat and ECOFYS estimates is likely to be for two key reasons:

1. In the ECOFYS study, it appears that the specific location of each energy-intensive plant is taken into account (and region-specific T&D costs applied)
2. In the ECOFYS study, it seems that they include exemptions for UK-based firms due to demand-side management through the UK's Triad system

The ECOFYS (2015) study appears to take account of the local transmission and distribution costs based on the specific location of each industrial plant. Energy consumption tariffs in the UK vary considerably across regional zones, with the cheapest network costs in Scotland and the highest network costs in the South West⁴⁹. The ECOFYS mapping appears to suggest that many of the energy-intensive industries are located in regions of the UK where network charges are lower and this could partly explain the discrepancy between the Eurostat and ECOFYS data.

Furthermore, it appears that the ECOFYS report takes account of T&D cost exemptions due to careful demand-side management through the UK's Triad system (cutting electricity demand during the three peak half-hourly electricity demand periods over November to February) and they receive substantial discounts on network costs by balancing electricity demand peaks in this way. It appears that the Eurostat data does not take this into account in their broader, 'industry average' estimates.

B.4 France

A comparison of the estimated network costs in France shows that Eurostat does reflect some exemptions on large industrial users but network costs in the Eurostat data are more than double the estimates presented in ECOFYS (2015).

⁴⁹ More information can be found in the Statement of Use of System Charges:

<http://www2.nationalgrid.com/UK/Industry-information/System-charges/Electricity-transmission/Transmission-Network-Use-of-System-Charges/Statement-of-Use-of-System-Charges/>

Appendix C Policy cost exemptions and compensation faced by industries in the UK

Table C.1 shows the policy cost exemptions and compensation applied to electro-intensive industry sectors in the UK in 2015, 2016, 2020, and 2030.

These are based on the policy details outlined in:

- BEIS (2016), 'Compensation for the indirect costs of the renewables obligation and small scale Feed-in-Tariffs'
- BIS (2015), 'Compensation for the indirect costs of EU Emissions Trading System and the Carbon Price Support mechanism from 2015'
- Environment Agency (2014), 'Reduced rate certificates: Climate Change Agreements'
- BEIS (2016) 'The Electricity Supplier Obligations (Amendment & Excluded Electricity) (Amendment) Regulations 2016'

For simplicity, we assume that firms in the eligible sectors will receive policy cost relief. This may not always be the case, as they are required to meet additional criteria to be eligible. These criteria are:

- For the Renewables Obligation, Feed-in-Tariffs and (post-2016) Contracts for Differences, electricity costs must be at least 20% of GVA
- For the EU Emissions Trading System and Carbon Price Support, the carbon cost element must be 5% of GVA

Table C.1 UK policy costs exemptions and compensation applied by year and sector

	2016			
	Climate Change Levy (CCL)	Contracts for Difference (CfD)	Renewable Obligations (RO) and Feed-in Tariffs (FiT)	Emission Trading System (ETS) and Carbon Price Support (CPS)
Steel EAF	100%	0%	85%	64%
Steel BOF	100%	0%	85%	64%
Industrial Gases	90%	0%	85%	0%
Fertilisers	90%	0%	85%	64%
Aluminium	100%	0%	85%	64%
Plastic Products	90%	0%	85%	0%
Paper and Pulp	90%	0%	85%	64%
Cement	100%	0%	85%	0%
Glass	100%	0%	85%	0%
Ceramics	100%	0%	85%	0%
Fabricated Metals	0%	0%	0%	0%

2020				
	Climate Change Levy (CCL)	Contracts for Difference (CfD)	Renewable Obligations (RO) and Feed-in Tariffs (FiT)	Emission Trading Scheme (ETS) and Carbon Price Support (CPS)
Steel EAF	100%	85%	85%	60%
Steel BOF	100%	85%	85%	60%
Industrial Gases	93%	85%	85%	0%
Fertilisers	93%	85%	85%	60%
Aluminium	100%	85%	85%	60%
Plastic Products	93%	85%	85%	0%
Paper and Pulp	93%	85%	85%	60%
Cement	100%	85%	85%	0%
Glass	100%	85%	85%	0%
Ceramics	100%	85%	85%	0%
Fabricated Metals	0%	0%	0%	0%
2030				
	Climate Change Levy (CCL)	Contracts for Difference (CfD)	Renewable Obligations (RO) and Feed-in Tariffs (FiT)	Emission Trading Scheme (ETS) and Carbon Price Support (CPS)
Steel EAF	100%	85%	85%	60%
Steel BOF	100%	85%	85%	60%
Industrial Gases	93%	85%	85%	0%
Fertilisers	93%	85%	85%	60%
Aluminium	100%	85%	85%	60%
Plastic Products	93%	85%	85%	0%
Paper and Pulp	93%	85%	85%	60%
Cement	100%	85%	85%	0%
Glass	100%	85%	85%	0%
Ceramics	100%	85%	85%	0%
Fabricated Metals	0%	0%	0%	0%

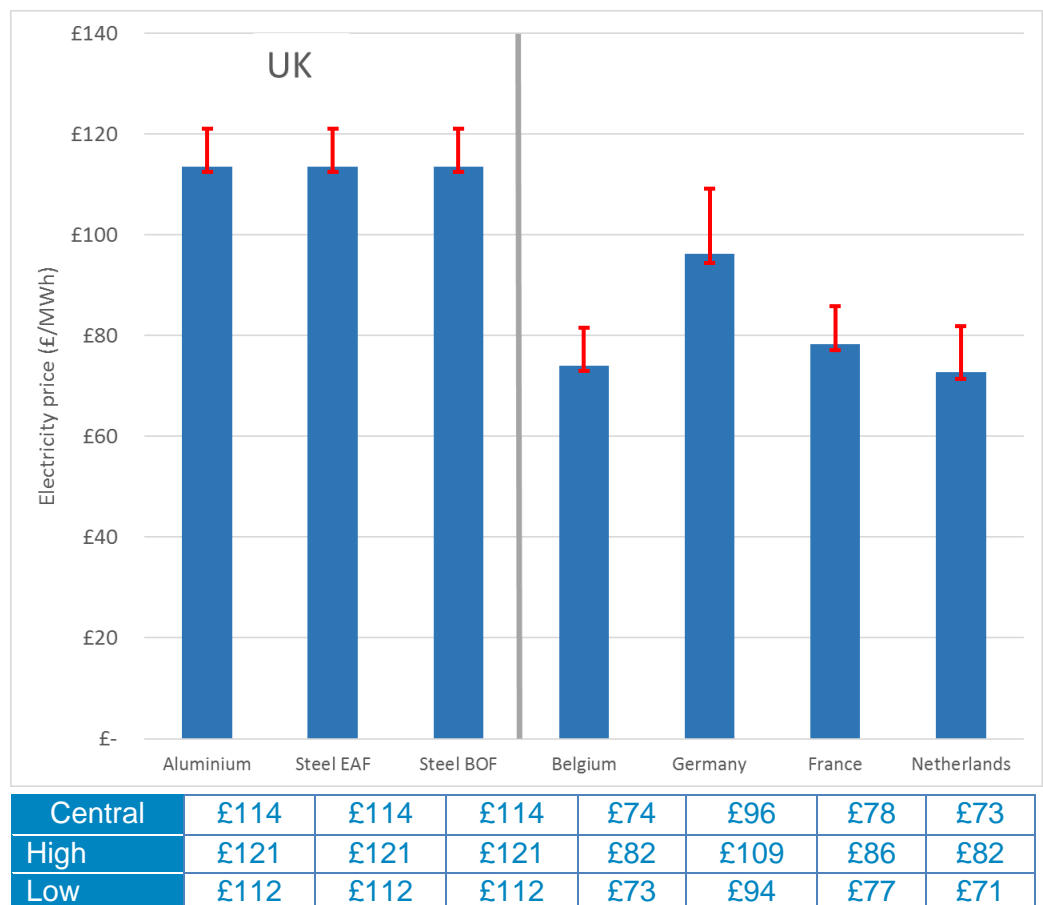
Source: Cambridge Econometrics, BEIS (2016)

Appendix D Results from sensitivity analysis on industrial electricity prices

D.1 Carbon price sensitivities

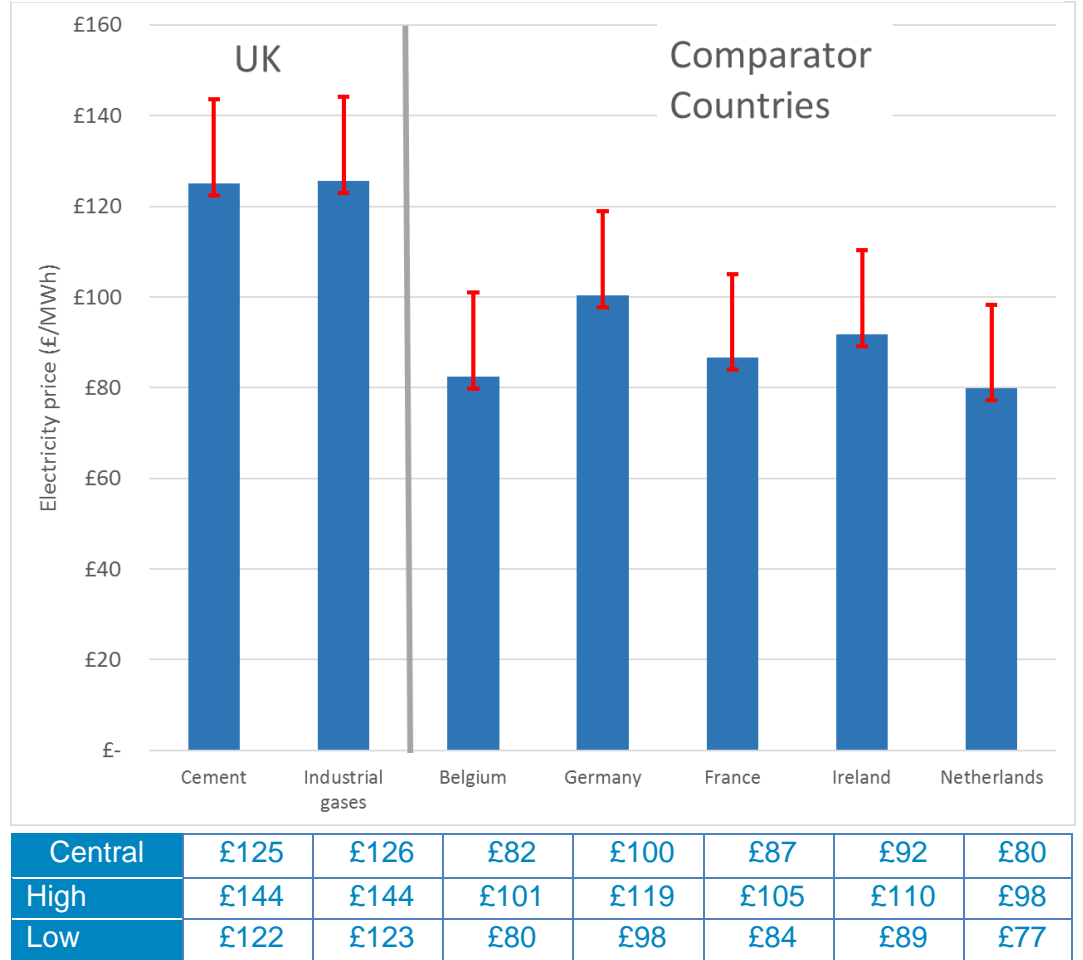
Figure D.1 and Figure D.2 show the results of sensitivities tested on the carbon price in 2030. The central carbon price assumption is based on BEIS (2016) projections and high and low variants are also taken from BEIS.

Figure D.1 Carbon price sensitivities for Profile 3 sectors with EU ETS compensation in 2030



Source: Cambridge Econometrics.

Figure D.2 Carbon price sensitivities for Profile 3 sectors without EU ETS compensation in 2030



Source: Cambridge Econometrics.

Appendix E Sectoral Findings

E.1 A note on GVA analysis

In the following sectoral analyses, sectoral GVA data is used as a metric to estimate relative value of over- and under- allocation to the size of the given sector. This analysis is intended to be illustrative of relative impacts across sectors, not to be a statement of the precise cost to sectors. The box below gives the data used in the analyses.

Table E.1 Gross Value Added (GVA) at basic prices data

NACE	GVA at basic prices (m 2016£) ⁵⁰	Year of data ⁵¹
17	3834	2014
19.2	2811	2015
20.1, 20.3, 20.4, 20.5	9011	2014
23.13	337	2014
23.31	96	2014
23.32	269	2014
23.51	177	2012
23.52	29	2012
24.1	938 ⁵²	2014

⁵⁰ ONS data adjusted to 2016 prices using EC's AMECO data

⁵¹ 2014 data was selected given that the 2016 ABS data for 2015 was provisional. Where 2014 data is unavailable, the proximate data was used. For the combined 2014 GVA measure in the cross-sectoral analysis, GVA was summed across these different years, to provide an estimate.

⁵² It should be noted that the closure of the Teesside Integrated Iron & Steel Works (Installation 12663) in 2015 has reduced output and GVA in the UK steel sector. Whilst it is beyond the scope of this analysis to estimate the impact of this closure on GVA in the UK steel sector, an indication of scale is that approximately 2000 jobs were lost in the Teesside closure; total employment in the UK steel sector in 2015 was approximately 31,000. See: https://teesvalley-ca.gov.uk/wp-content/uploads/2016/03/tees_valley_economic_assessment_2015_full.pdf & <https://researchbriefings.files.parliament.uk/documents/CBP-7317/CBP-7317.pdf>.

E.2 Findings for the Steel Sector

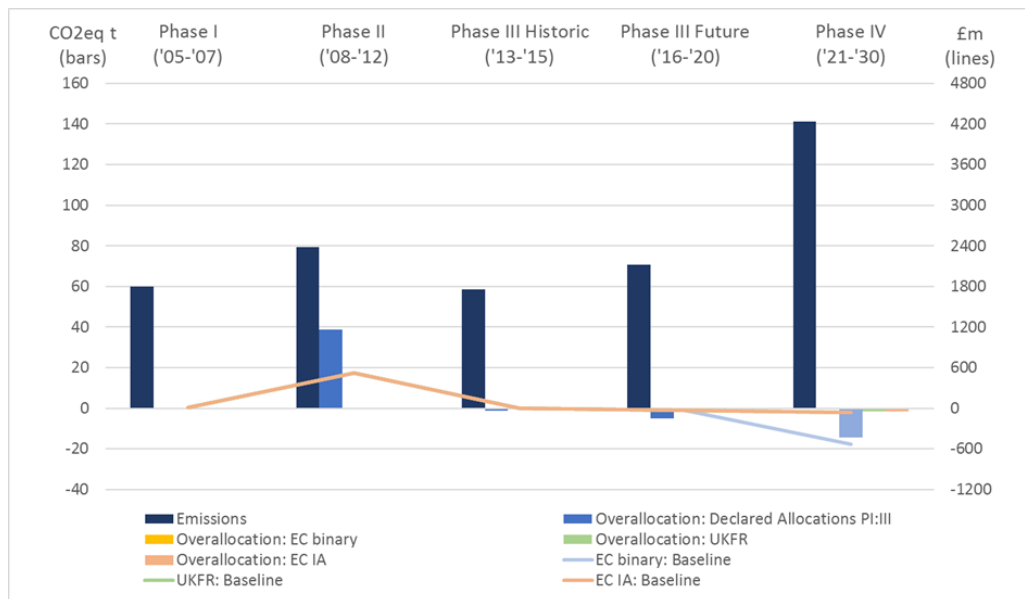
In Phase I (2005-2007), the trial period of the EU ETS, the steel sector’s allocation matched its verified emissions, which can be explained by backward planning for the trial period. In Phase II (2008-2012) the permit overallocation was significant, 36 million tonnes of CO₂e of £700m value. To some extent, this is the result of the global economic downturn.

Phase III historic emissions matched the sector’s allocation, suggesting that the allocation mechanism has been effective.

In Phase II the extent of the UK steel sector’s overallocation was over 48% of emissions, while in Phase I and Phase III up to 2016 it has been insignificant. In future for Phase III a small deficit of allowances is likely, assuming constant production and emissions levels; under the baseline price projections the steel sector’s under-allocation is below 4% of 2014 GVA.

Phase IV (2020-2030) will see a greater deficit of 14.5 million tonnes of CO₂e, if in the binary approach sector benchmarks are reduced by 7.5% between 2021 and 2025, and 10% between 2026 and 2030, on 2008 levels (i.e. 0.5% per annum), to account for anticipated emission reductions through technological progress.

Figure A.3 Emissions, extent and value of ETS permit over- and under-allocation in the steel sector between 2005-2030, baseline prices under different carbon leakage scenarios



Analysing the value of future ETS permit deficit, four ETS price projections were used as set out above. As for the binary approach, for the tiered approaches, all benchmark calculations were reduced by 7.5% between 2021 and 2025 and 10% between 2026 and 2030, based on 2008 levels (i.e. 0.5% per annum (see Figure A.4 for Phase III and Figure A.5 for Phase IV).

- 1 The low price scenario (assuming prices remain constant after 2016 and allocation is based on the Commission’s proposal with the binary leakage criteria) would mean no significant under-allocation to the UK steel sector

in Phase III and in Phase IV under the tiered scenarios. Calculated based on the EC binary proposal, the UK steel sector would have to pay additional costs of over £80m.

- 2 Under the baseline price scenario, the value of 5 million additional permits to cover future Phase III under allocation, costs the steel sector over £30m, approximately 3% of 2014 GVA. In Phase IV, under both tiered scenarios the UK steel sector would have additional costs of £60m; approx. 7% of 2014 GVA. While under the EC binary proposal, costs would be over eight times more at £530m.
- 3 Using the PRIMES projected prices, UK steel sites would need to spend over £54m on permits in Phase III, approx. 6% of 2014 GVA. In Phase IV, under both tiered scenarios the UK steel sector would have additional costs of almost £43m. While under the EC binary proposal, costs would be over £360m.
- 4 Assuming a high ETS price, the costs for the steel sector would amount to over £150m by 2020, approx. 16% of 2014 GVA. In Phase IV, under both tiered scenarios the UK steel sector would have additional costs of £160m; just over 17% of 2014 GVA. While under the EC binary proposal, costs would be £1.38bn; over 146% of 2014 GVA.

Figure A.4 Extent and value of ETS permit over- and under-allocation in the steel sector between 2005-2020, under different price projections

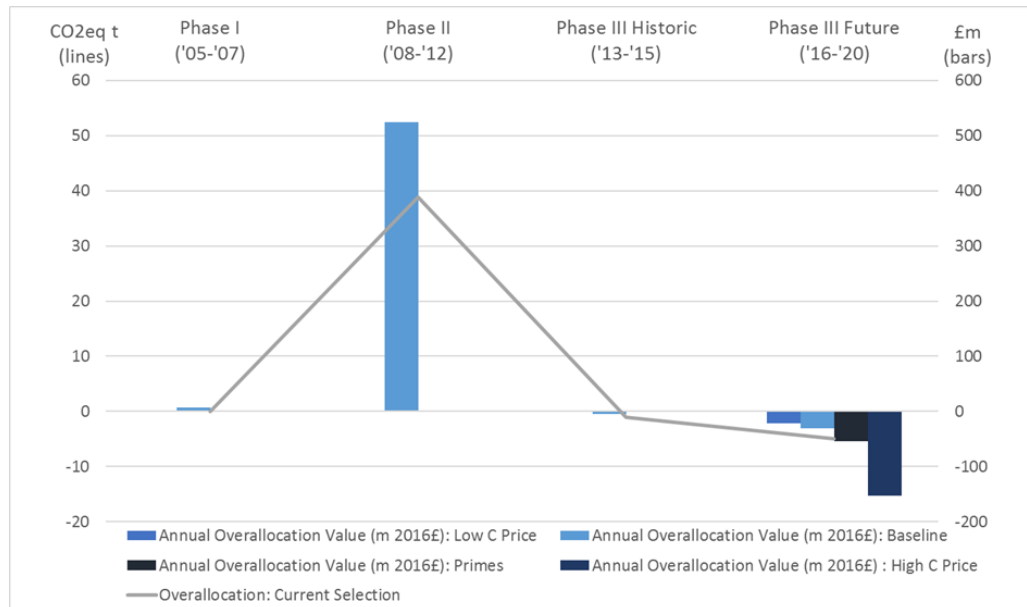
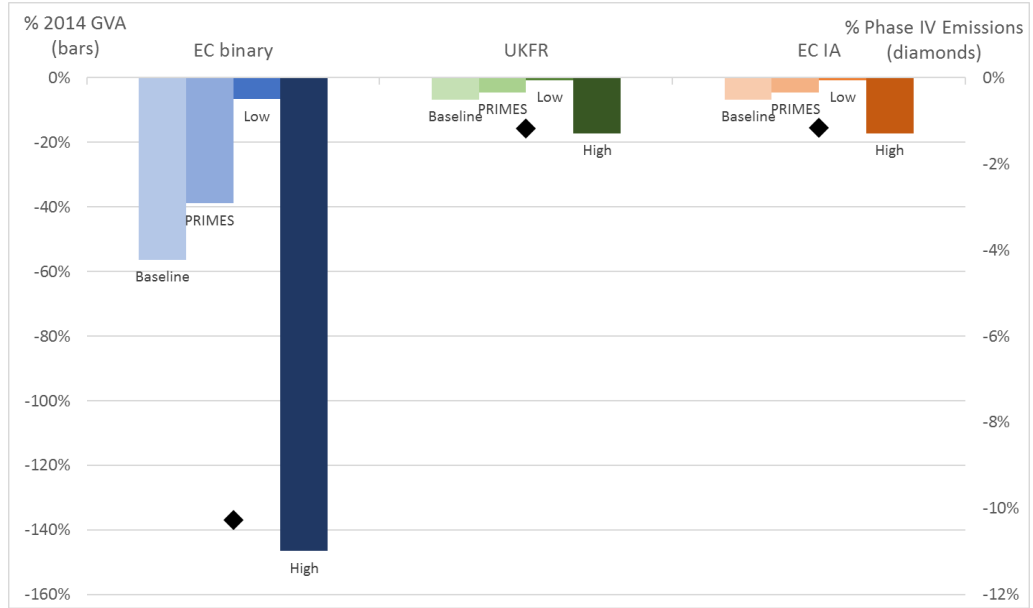
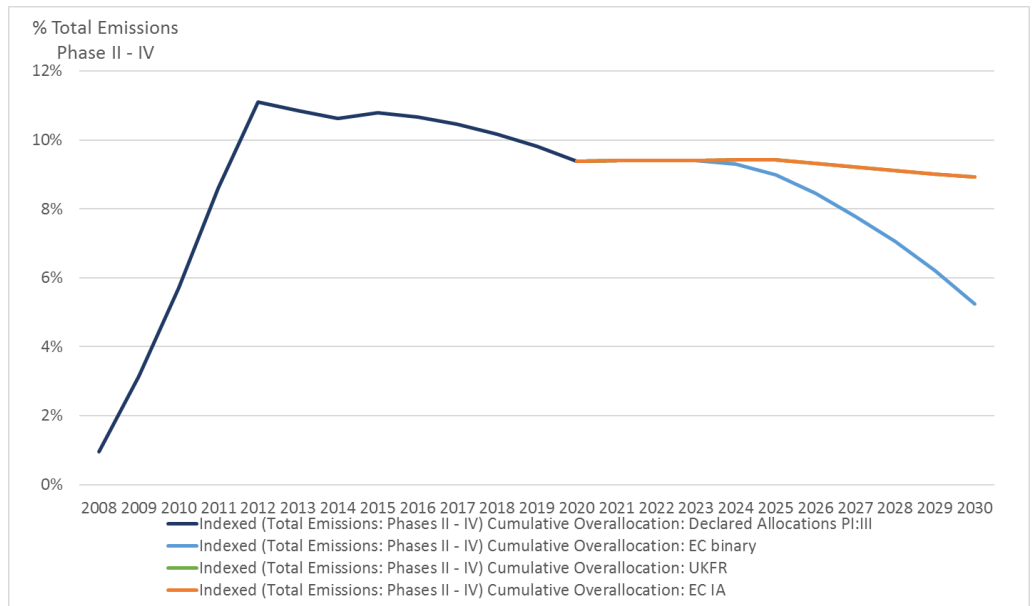


Figure A.5 Value of ETS permit under-allocation in the steel sector in Phase IV, under different price projections and different carbon leakage treatment scenarios, and its relative size to 2014 GVA (bars) and emissions (diamonds).



The evidence is that the EC’s binary proposal would yield the largest under-allocation for the steel sector. This is because the binary approach is less discriminatory with regards to sectors’ eligibility for free allocations, triggering the CSCF from 2024 onwards, which reduces all installations’ allocations against their benchmarks proportionally. The tiered approaches are more generous to the steel sector because the CSCF is not required and steel is in the high risk tier in both tiered proposals; so installations would receive free allocations amounting to 100% of the benchmark.

Figure A.6 Cumulative overallocation in the steel sector under full banking



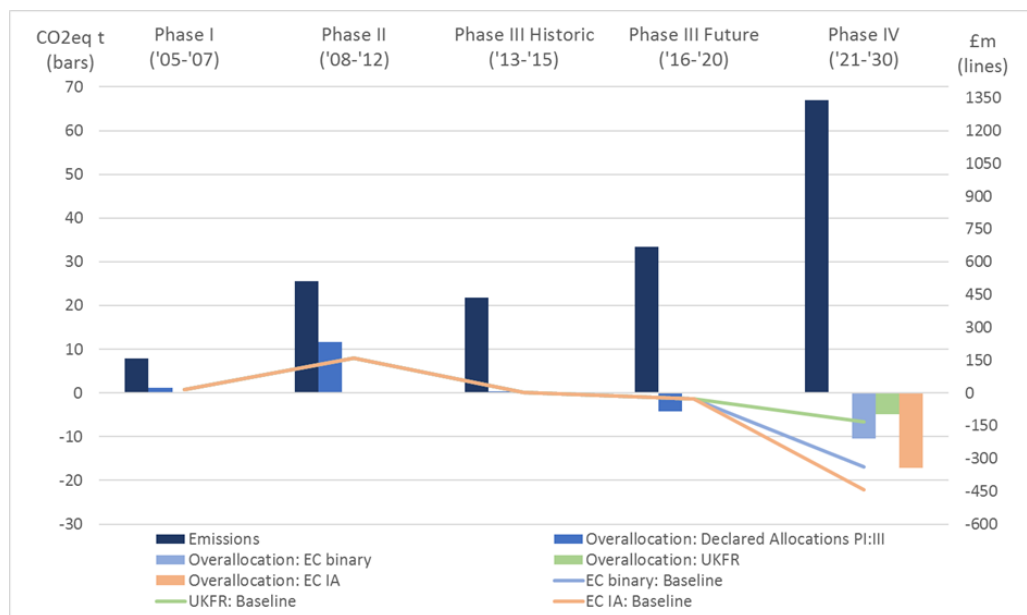
The steel sector’s overallocation would more than cover its projected deficit in all Phase IV scenarios – assuming full banking of unused allowances.

E.3 Findings for the Chemical Sector

In Phase I (2005-2007), the trial period of the EU ETS, the chemical sector’s allocation was 1 million tonnes of CO₂e more than its verified emissions. In Phase II (2008-2012) the permit overallocation was 11 million tonnes of CO₂e with a value of over £150m. The overallocation seems to be a result of falling output and therefore a decrease in emissions, as a result of the global economic downturn. Phase III historic emissions matched the sector’s allocation.

In future, for Phase III a small deficit of allowances is likely, 4 mtCO₂e, assuming constant production and emissions. Phase IV (2020-2030) will see a greater deficit of 10.5m tCO₂e, assuming that in the binary approach sector benchmarks are reduced by 7.5% between 2021 and 2025 and 10% between 2026 and 2030, based on 2008 levels (i.e. 0.5% per annum), to account for expected emission reductions through technological progress.

Figure A.7 Emissions, extent and value of ETS permit over- and under-allocation in the chemical sector between 2005-2030, baseline prices under different carbon leakage scenarios



Analysing the value of future deficit of ETS permits, four ETS price projections were used as set out above. For the tiered approaches, all benchmark calculations were reduced by 7.5% between 2021 and 2025 and 10% between 2026 and 2030, based on 2008 levels (see Figure A.8 for Phase III and Figure A.9 for Phase IV).

- 1 The low-price scenario (assuming prices remain constant after 2016) would mean £18m additional costs for the UK chemical sector in Phase III. In Phase IV, costs would be highest under the EC tiered scenario at around £75m, 0.8% of 2014 GVA. Calculated based on the binary proposal, the UK chemical sector would have to pay additional costs of

£45m; approx. 0.5% of 2014 GVA. The UK FR proposal would mean lower cost, around £20m, 0.1% of 2014 GVA.

- 2 Under the baseline scenario, the value of additional permits for the remainder of Phase III is over £25m, approximately 0.3% of 2014 GVA. In Phase IV, costs would be highest under the EC tiered scenario, around £440m. Calculated based on the binary proposal, the UK chemical sector would have to pay additional costs of £335m. The UK FR proposal would mean lower costs, over £130m.
- 3 Using the PRIMES projected prices the ETS has a direct impact in Phase III, where UK chemical sites would need to spend over £44m on permits, approx. 0.5% of GVA. In Phase IV, costs would be highest under the EC tiered scenario, around £365m. Calculated based on the binary proposal, the UK chemical sector would have to pay additional costs of £248. The UK FR proposal would mean lower costs, approx. £100m.
- 4 Assuming a high ETS price, the costs for the chemical sector would amount to over £120m by 2020, approx. 1.3% of 2014 GVA. In Phase IV, costs would be highest under the EC tiered scenario, around £1.35bn, over 15% of 2014 GVA. Calculated based on the binary proposal, the UK chemical sector would have to pay additional costs of £925m. The UK FR proposal would mean lower costs, less than £400m.

Figure A.8 Extent and value of ETS permit over- and under-allocation in the chemical sector between 2005-2020, under different price projections

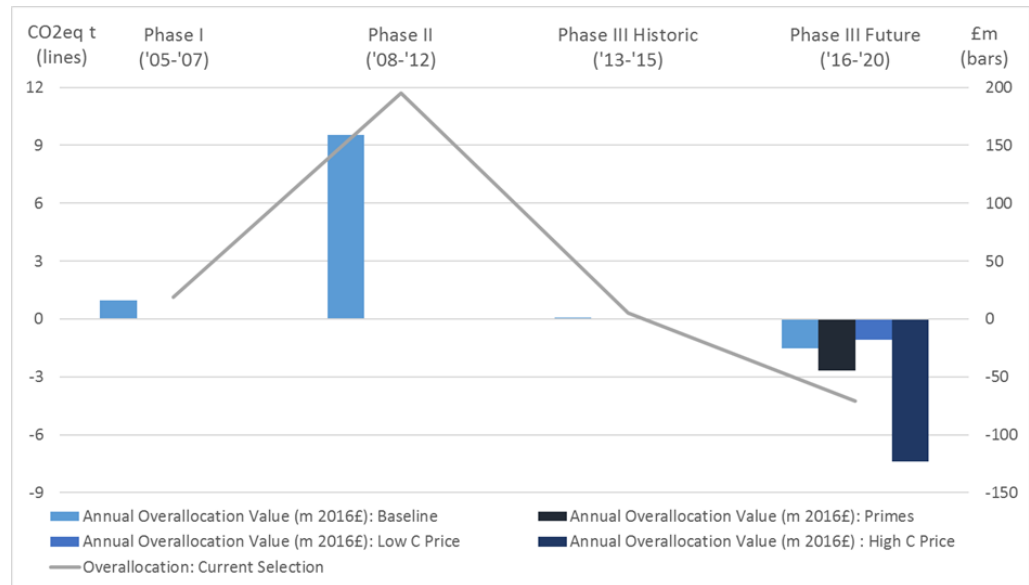
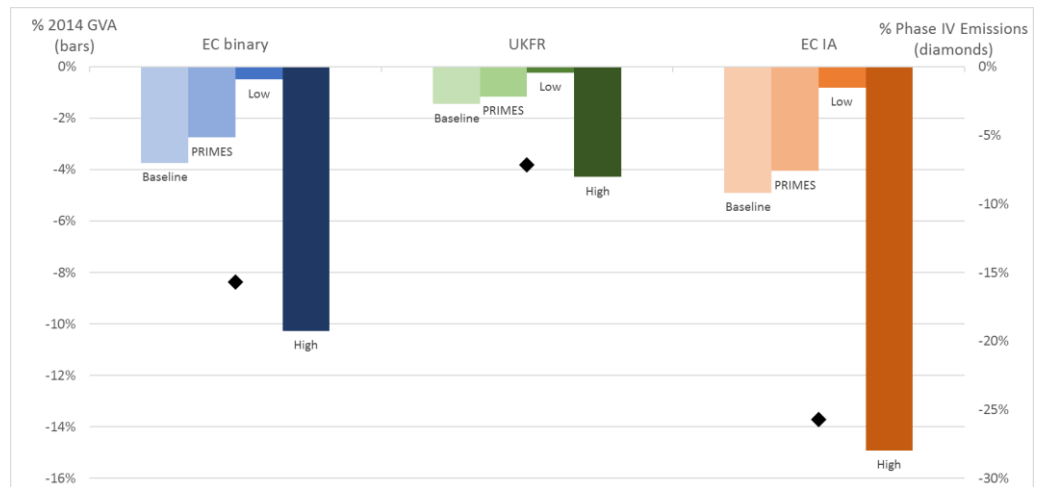


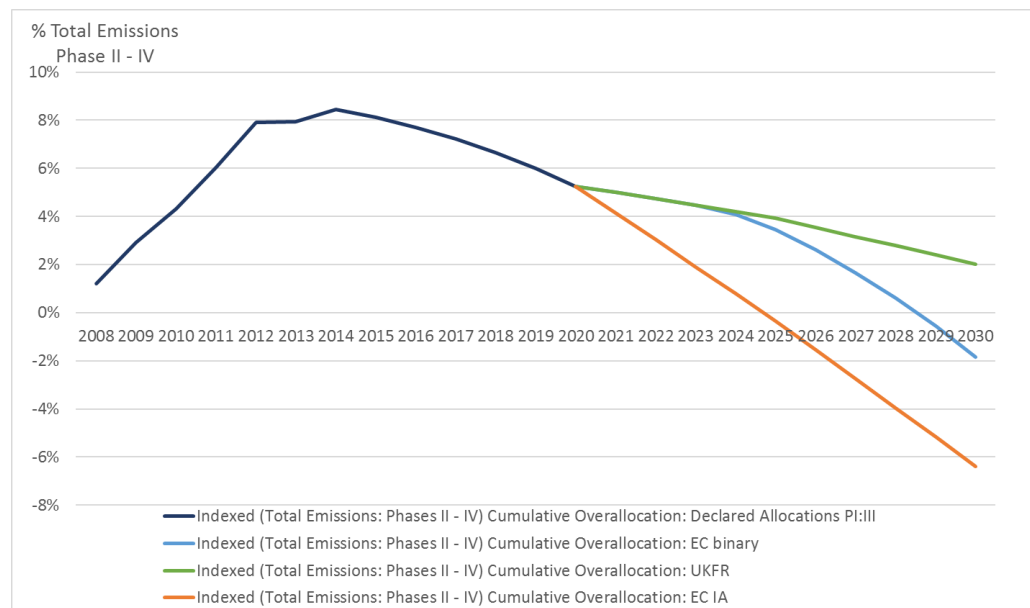
Figure A.9 Value of ETS permit under-allocation in the chemical sector in Phase IV, under different price projections and different carbon leakage treatment scenarios, and its relative size to 2014 GVA (bars) and emissions (diamonds)



The chemical sector is in the high-risk tier in the UK/FR proposal, hence it receives 100% free allocation, so this is the most generous scenario compared with the other two scenarios. The most stringent is the EC IA proposal's tiered approach where chemicals (excluding 20.6) are included in the medium tier, receiving 80% free allocation. The Commission's binary approach is in the middle, giving 100% free allocation, corrected with the CSCF.

Assuming full banking of unused allowances, the chemicals sector's overallocation would cover its projected deficit under the UK/FR proposal, while under the EC IA and EC binary proposal it would be under-allocated from 2025 and 2028 respectively.

Figure A.10 Cumulative overallocation in the chemicals sector under full banking



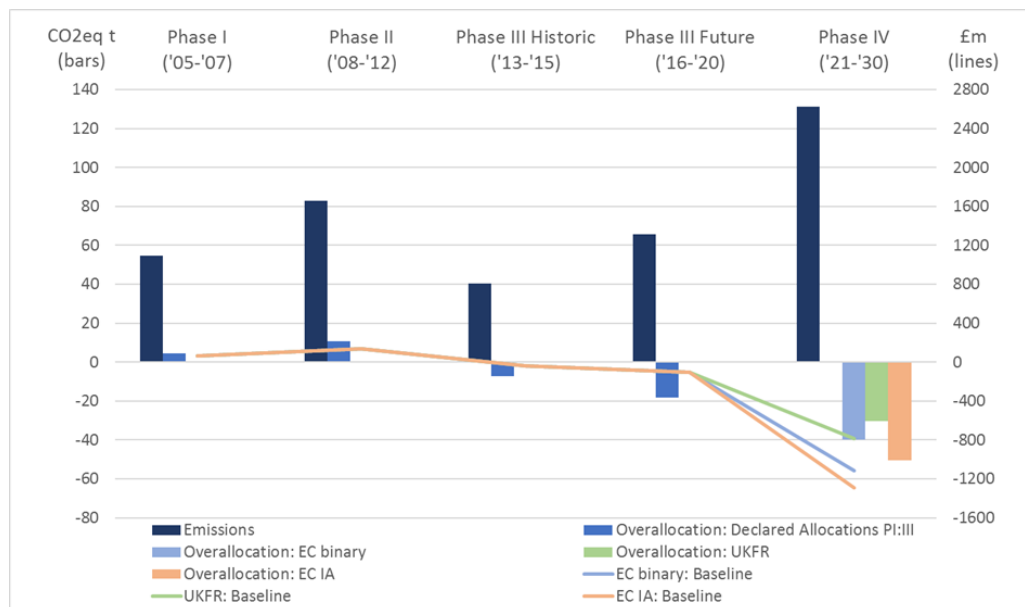
E.4 Findings for the Refinery Sector

In Phase I (2005-2007), the trial period of the EU ETS, the refinery sector’s allocation was 4.5 million tonnes of CO2e more than its verified emissions, amounting to a potential £60m. In Phase II (2008-2012) the permit overallocation was over 11 million tonnes of CO2e with a value of over £139m. This was -most probably- the result of the global economic downturn.

Phase III historic emissions were 7.2m t over the sector’s allocation, costing £37m for UK refineries.

In future for Phase III a deficit of 18m tCO2e is projected, assuming constant production and emissions. Phase IV (2020-2030) will see a greater deficit, between 30m and 50m tCO2e, depending on the Phase IV allocation measures.

Figure A.11 Emissions, extent and value of ETS permit over- and under-allocation in the refinery sector between 2005-2030, baseline prices under different carbon leakage scenarios



Analysing the value of future ETS permit deficits of, four ETS price projections were used as set out above. For each scenario, all benchmark calculations were reduced by 7.5% (between 2021 and 2025) and 10% (between 2026 and 2030) on 2008 levels (see Figure A.12 for Phase III and

Figure A.13 for Phase IV).

- 1 The low price scenario (assuming prices remain constant after 2016 and allocation is based on the Commission’s proposal with the binary leakage criteria) would mean over £75m additional costs for the UK refinery sector in Phase III. In Phase IV, costs would be most under the EC tiered scenario, around £200m, which is under 8% of 2015 GVA. Calculated based on the binary proposal, the UK chemical sector would have to pay additional costs of £170m. The UK FR proposal would mean least costs, around £130m.

- 2 Under the baseline scenario, the value of additional permits is over £100m. In Phase IV, costs would be highest under the EC tiered scenario, at around £1.3bn, which is almost 46% of 2015 GVA. Calculated based on the binary proposal, UK refineries would have to pay additional costs of £1.1bn. The UK FR proposal would mean lower costs, over £784m, 28% of GVA.
- 3 Using the PRIMES projected prices the ETS has a detrimental direct impact in Phase III, UK refineries would need to spend over £180m on permits. In Phase IV, costs would be most under the EC tiered scenario, around £1bn, below 40% of GVA. Calculated based on the binary proposal, UK refineries would have to pay additional costs of £880m; approx. 31% of GVA. The UK FR proposal would mean least costs, £780m.
- 4 Assuming a high ETS price, the costs for refineries would amount to over £500m by 2020. In Phase IV, costs would be most under the EC tiered scenario, around £3.9bn, 140% of 2015 GVA. Calculated based on the binary proposal, UK refineries would have to pay additional costs of £3.25bn. The UK FR proposal would mean least costs, £2.4bn.

Figure A.12 Extent and value of ETS permit over- and under-allocation in the refinery sector between 2005-2020, under different price projections

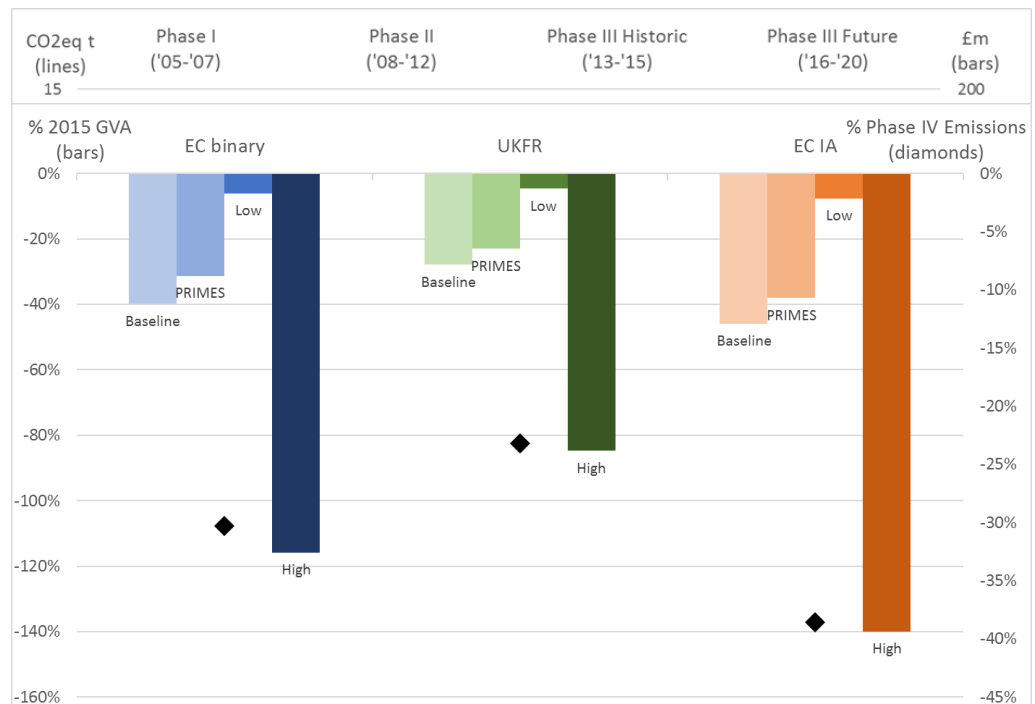


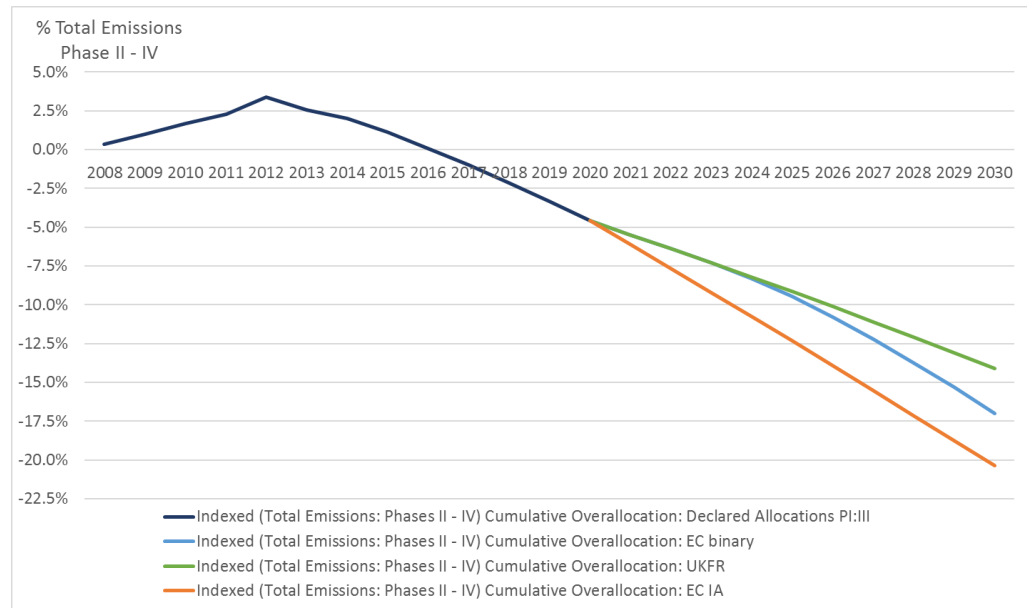
Figure A.13 Value of ETS permit under-allocation in the refinery sector in Phase IV, under different price projections and different carbon leakage treatment scenarios, and its relative size to 2014 GVA (bars) and emissions (diamonds)

The refinery sector is in the high-risk tier in the UK/FR proposal, hence it receives 100% free allocation. This is the most generous compared with the other two scenarios. The most stringent is the EC IA proposal's tiered approach where refineries are included in the medium tier, receiving 80% free

allocation. The Commission’s binary approach gives 100% free allocation, corrected with the CSCF.

The refinery sector is most affected by under-allocation, even assuming full banking, the unused allowances would have run out in 2016 and a 4.6% deficit over total emissions 2008-2030 is projected by the end of Phase III. Phase IV would see an even larger deficit, ranging from 14% to 20% by 2030, the end of Phase IV.

Figure A.14 Cumulative allocation in the refinery sector under full banking



E.5 Findings for the Paper & Pulp Sector

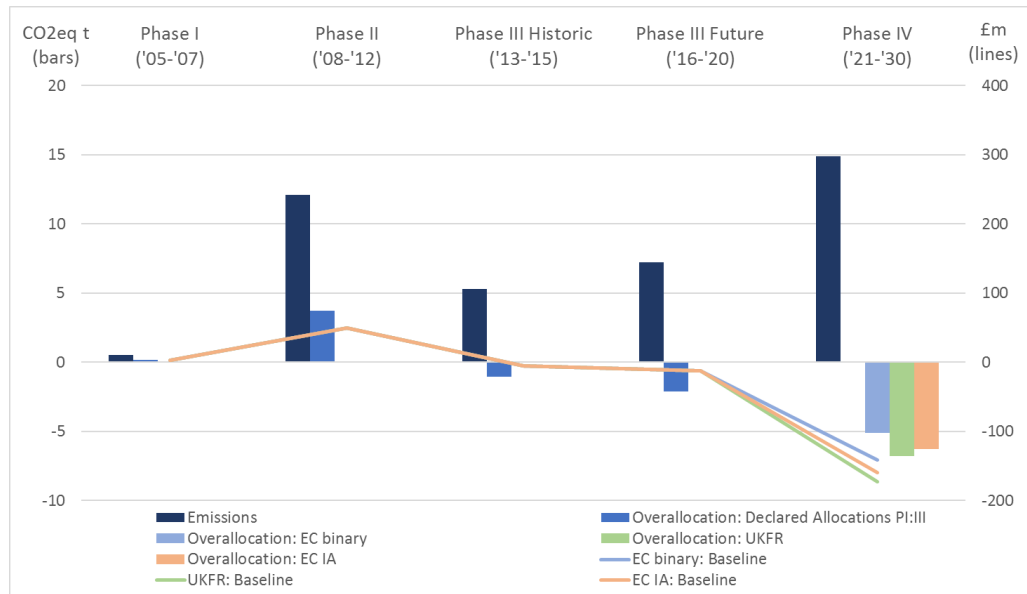
The paper & pulp sector is characterised by many mills having third party CHP plants either on the installation’s site or adjacent, which provide heat and power. This analysis has removed CHP installations where possible; given the co-reporting of data between mills and CHP plants, however, this was not possible for the paper & pulp sector. This property of the sector also results in a more complicated relationship between the UK’s Climate Change Agreements policy and the EU ETS. These caveats should be noted when considering this analysis.

In Phase I (2005-2007), the trial period of the EU ETS, the paper & pulp sector’s allocation was 170,000 tonnes of CO₂e more than its verified emissions, with a potential value of £3m. In Phase II (2008-2012) the permit overallocation was over 3.7 million tonnes of CO₂e with a value of over £49m. As with other sectors, this is likely to be a result of the global economic downturn.

Phase III historic emissions were 1 mtCO₂e below the sector’s allocation, with a value of £5m for the UK paper industry.

In future, for Phase III, a deficit of 2.1 mtCO₂e is projected, assuming constant production and emissions. Phase IV (2020-2030) would see a deficit of between 5.1 and 6.8 mtCO₂e, depending on the Phase IV allocation measures.

Figure A.15 Emissions, extent and value of ETS permit over- and under-allocation in the paper & pulp sector between 2005-2030, baseline prices under different carbon leakage scenarios



Analysing the value of future ETS permit deficits, four ETS price projections were used as set out above. For all approaches, all benchmark calculations were reduced by 7.5% between 2021 and 2025 and 10% between 2026 and 2030 on 2008 levels (see Figure A.16 for Phase III and Figure A.17 for Phase IV).

- 1 The low-price scenario (assuming prices remain constant after 2016 and allocation is based on the Commission’s proposal with the binary leakage criteria) would mean over £9m additional costs for the UK Paper & Pulp industry in Phase III. In Phase IV, costs would be highest under the UK/FR tiered scenario, around £29m, which is below 0.8% of 2014 GVA. Calculated based on the tiered proposal and on the EC’s impact assessment (EC IA), the UK paper industry would have to pay additional costs of £27m. The EC binary proposal would mean least costs, around £22m.
- 2 Under the baseline scenario, the value of additional permits required in Phase III is over £12m. In Phase IV, costs would be highest under the UK/FR tiered scenario, around £173m. The sector would receive about 6.8m t less than the projected emissions. Calculated using the EC IA proposal, UK paper & pulp firms would have to pay additional costs of £159m as the sector would receive 6.25m fewer permits than needed. The EC binary proposal would mean lower costs, almost £141m to cover around 5.1m permits.
- 3 Using the PRIMES projected prices, in the remainder of Phase III the UK paper industry would need to spend over £21.5m on permits. In Phase IV, costs would be highest under the UK/FR tiered scenario, around £144m, approx. 3.7% of 2014 GVA. Calculated based on the EC IA proposal, the UK paper sector would have to pay additional costs of £132m. The EC binary proposal would mean lower costs of £112m.
- 4 Assuming a high ETS price, the costs for the paper installations would amount to over £58m by 2020. In Phase IV, costs would be highest under the UK/FR tiered scenario, around £528m. Calculated based on the EC IA tiered proposal, the UK paper sector would have to pay additional costs of £486m. The EC binary proposal would mean least costs, at £413m.

Figure A.16 Extent and value of ETS permit over- and under-allocation in the paper & pulp sector between 2005-2020, under different price projections

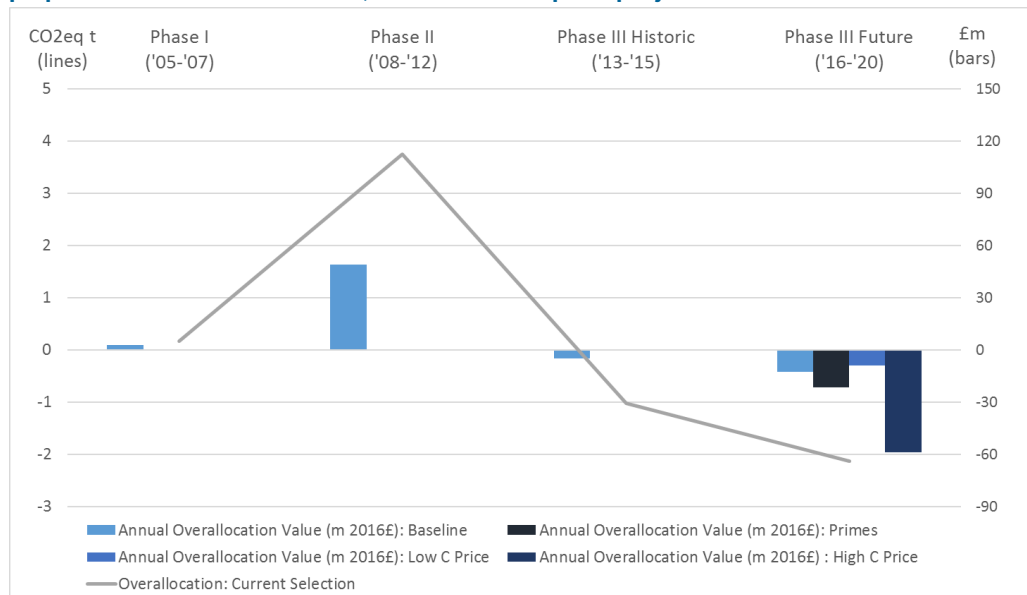
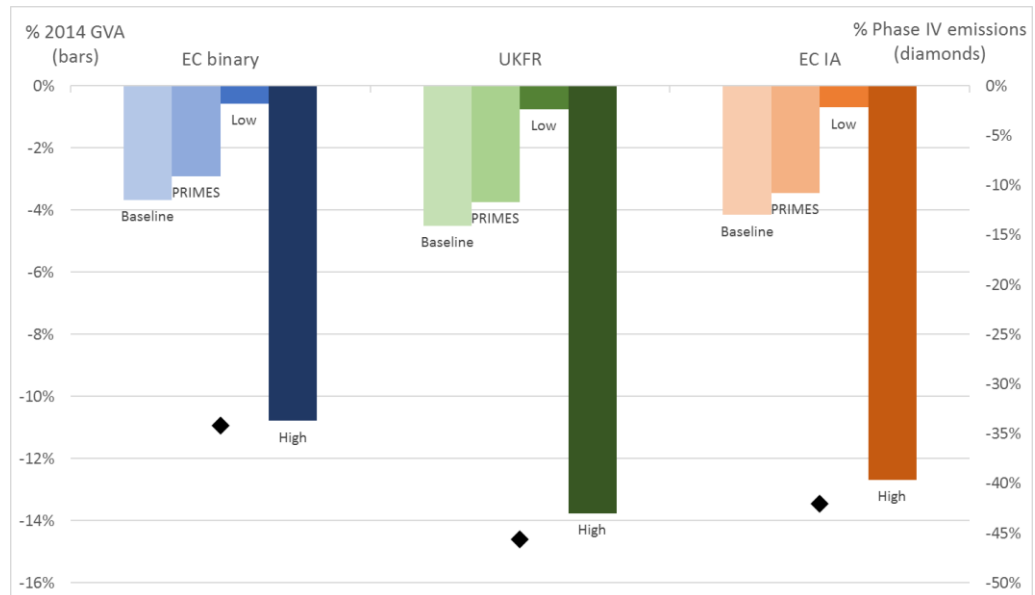


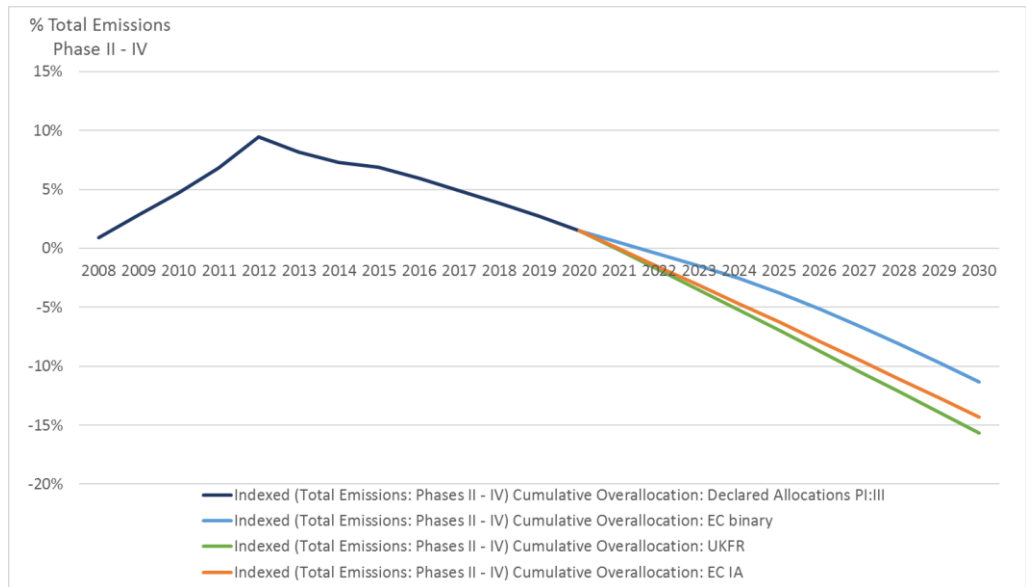
Figure A.17 Value of ETS permit under-allocation in the paper & pulp sector in Phase IV, under different price projections and different carbon leakage treatment scenarios, and its relative size to 2014 GVA (bars) and emissions (diamonds)



The paper sector is in the middle risk tier in both tiered proposals. In the UK/FR proposal it receives 75% free allocation, so this is the least generous compared with the other two scenarios. In the tiered proposal based on the EC's impact assessment (EC IA) paper pulp installations receive 80% free allocation. The Commission's binary approach gives 100% free allocation, corrected with the CSCF, hence this is the most generous approach for the paper and pulp sector.

Assuming full banking of unused allowances, the paper and pulp sector's overallocation would only cover its projected deficit to 2022 under the EC binary proposal, while under the UK/FR and EC IA proposal it would be under-allocated from 2021.

Figure A.18 Cumulative overallocation in the paper & pulp sector under full banking



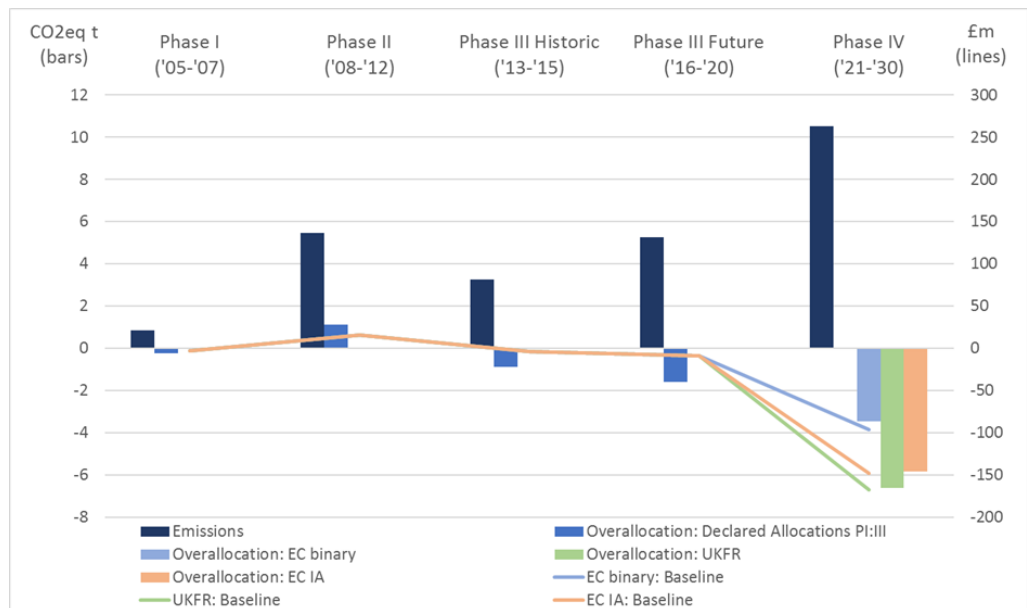
E.6 Findings for the Hollow Glass Sector

In Phase I (2005-2007), the trial period of the EU ETS, the hollow glass sector’s allocation almost covered its verified emissions. In Phase II (2008-2012) there was a permit overallocation of 11m tonnes of CO₂e of £15m value. As this was the case for most sectors it seems reasonable to attribute this to the effects of the global economic downturn on production. Phase III historic emissions were 800,000 tonnes higher than the sector’s allocation.

In Phase II the value of the sector’s overallocation was approx. 4.5% of its 2014 GVA. In future, for Phase III, a deficit of allowances is likely (1.5m tonnes), assuming constant production and emissions. Up to 2020, under the different price projections the hollow glass installations’ under-allocation ranges from 2% to 13% of its 2014 GVA.

Phase IV (2020-2030) will see a greater deficit of 3.5m tonnes of CO₂e, assuming that in the binary approach sector benchmarks are reduced by 7.5% between 2021 and 2025, and 10% between 2026 and 2030, on 2008 levels (i.e. 0.5% per annum), to account for expected emission reductions through technological progress.

Figure A.19 Emissions, extent and value of ETS permit over- and under-allocation in the hollow glass sector between 2005-2030, baseline prices under different Phase IV scenarios



Analysing the value of future ETS permit deficits, four ETS price projections were used as set out above. For the tiered approaches, all benchmark calculations were the same as for the EC binary scenario (see Figure A.20 for Phase III and Figure A.21 for Phase IV).

- 1 Assuming a low ETS price, the costs for the hollow glass sector in the remainder of Phase III would amount to £6.8m by 2020. Under a low ETS price and the EC binary scenario the UK hollow glass installations would face the lowest cost in Phase IV, £15m, approx. 4.5% GVA, to pay for the

3.5m CO₂eq t under-allocation. Calculating the tiered proposals, the sector would have to pay around £25m.

- 2 Under the baseline carbon price scenario, the cost of under-allocation for the remainder of Phase III is £9.5m, approx. 3% of 2014 GVA. The cost of funding the allocation shortfall under the EC binary scenario in Phase IV, for the baseline carbon price, is over £96m, approx. 29% of 2014 GVA. Under the EC IA tiered scenario, the sector would have additional costs of £150m to cover 5.9m tonnes of under-allocation. While under the UK/FR proposal costs would be £170m to purchase 6.6m permits to fund the under-allocation of the sector.
- 3 Using the PRIMES projected prices the cost to the sector in Phase III is £16m. In Phase IV, under the EC binary scenario the cost of under allocation to the cement sector is £76m. Costs are higher under both tiered scenarios, EC IA and UK/FR, with values of £124m and £140m respectively.
- 4 Assuming a high ETS price, the costs for the cement sector would amount to over £44m by 2020, approx. 13% of 2014 GVA. In Phase IV, under the EC binary scenario the UK cement sector would have additional costs of £282m. Under the EC IA tiered scenario, costs would be £450m; while the UK/FR scenario would be over £510m.

Figure A.20 Extent and value of ETS permit over- and under-allocation in the hollow glass sector between 2005-2020, under different price projections

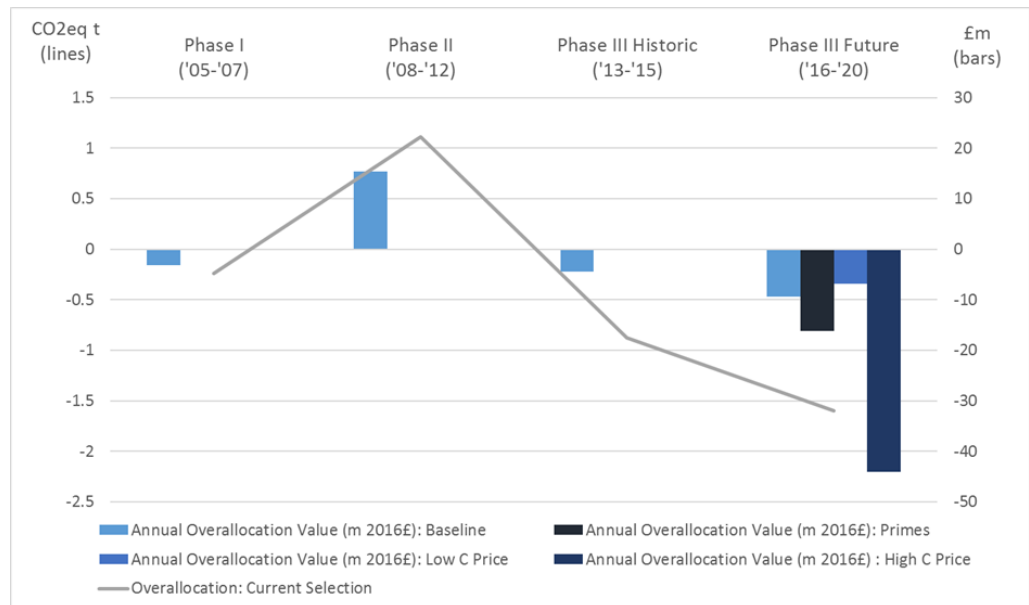
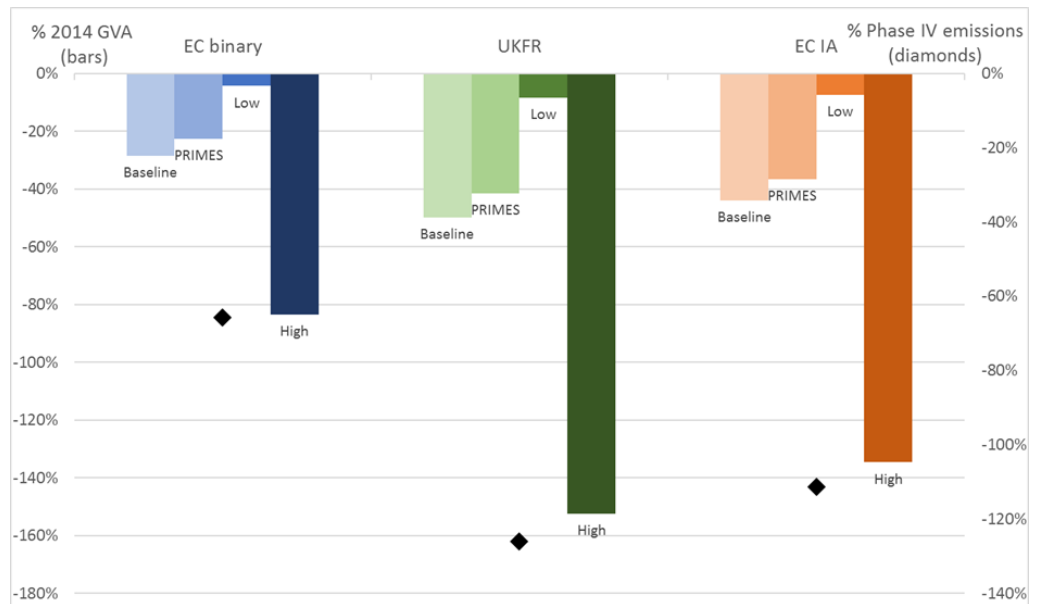


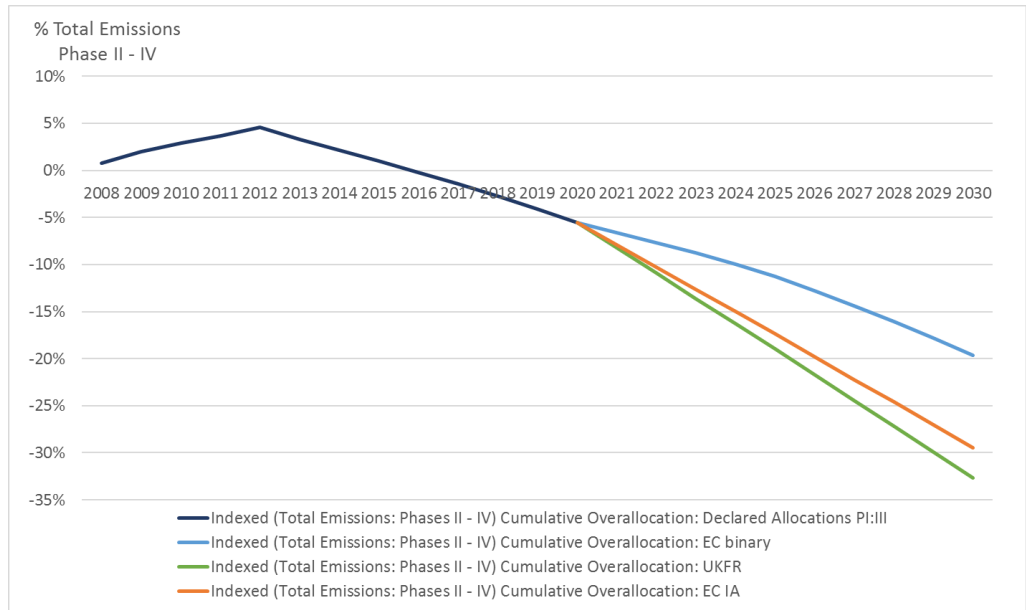
Figure A.21 Value of ETS permit under-allocation in the hollow glass sector in Phase IV, under different price projections and different carbon leakage treatment scenarios, and its relative size to 2014 GVA (bars) and emissions (diamonds)



The hollow glass sector is in the low risk tier in both UK/FR and EC IA proposal classifications. The most generous scenario is the EC binary scenario; but even under this scenario the sector is likely to receive fewer permits than needed. The most stringent scenario is the UK/FR scenario where installations receive only 50% of their benchmarks, while the EC IA scenario would allocate up to 60% of the benchmarks for free.

The hollow glass sector is affected by under-allocation, even assuming full banking, the unused allowances would have run out in 2016 and more than 5% deficit vs 2008-2030 emissions is projected by the end of Phase III. Phase IV would see an even larger deficit, ranging from 19% to over 32% by 2030, the end of Phase IV.

Figure A.22 Cumulative overallocation in the hollow glass sector under full banking



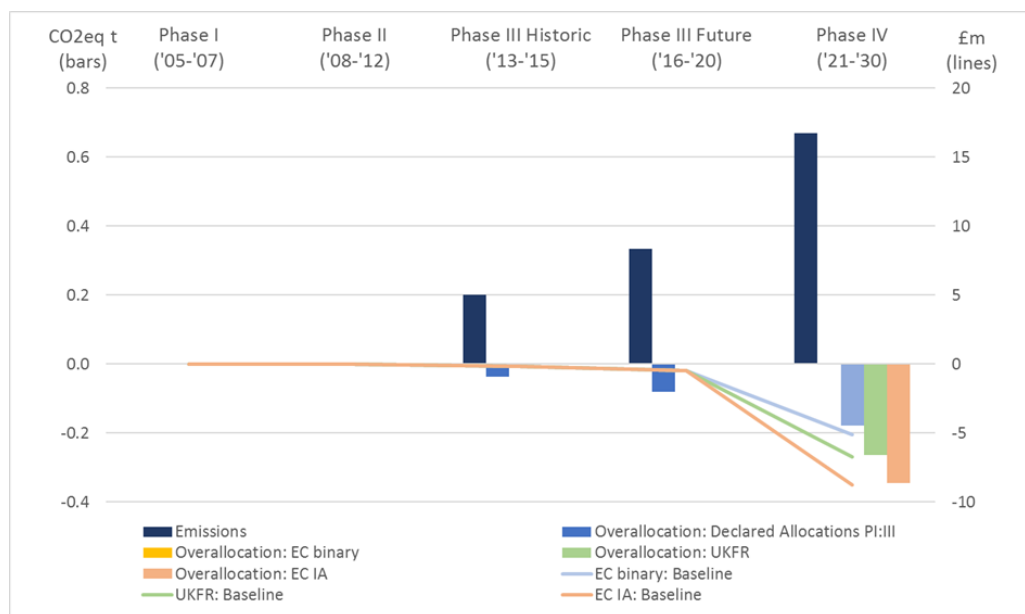
E.7 Findings for the Ceramic Tiles and Flags Sector

The first point to note for the ceramic tiles & flags sector is that there are only two installations in the UK in the EU ETS. This analysis therefore, is limited in scope of applicability. The second point to note is that data for these installations only starts from 2013, the start of Phase III.

Historic Phase III allocation was 36,000 tonnes lower than verified emissions, which translates to a potential cost of £0.2m.

Going forward, for Phase III, a deficit of allowances is likely (80,000 tonnes), assuming constant production and emissions. Phase IV (2020-2030) will see a greater deficit of 180,000-345,000 tonnes of CO₂e, depending on the policy chosen.

Figure A.23 Emissions, extent and value of ETS permit over- and under-allocation in the ceramic tiles & flags sector between 2005-2030, baseline prices under different Phase IV scenarios



Analysing the value of future ETS permit deficits, four ETS price projections were used as set out above. For each approach, benchmark calculations were reduced by 7.5% for the first half of Phase IV, and 10% for the second (see Figure A.24 for Phase III and Figure A.25 for Phase IV).

- 1 Assuming a low ETS price, the costs for the ceramic tiles sector in the remainder of Phase III would amount to £0.3m by 2020. Under a low ETS price and the EC binary scenario the UK ceramic tiles installations would face the lowest cost in Phase IV, £0.8m. Calculating the tiered proposals, the sector would have to pay approx. £1.1m and £1.5m for the UK/FR & EC IA proposals respectively.
- 2 Under the baseline carbon price scenario, the cost of under-allocation for the remainder of Phase III is £0.5m, approx. 0.5% of 2014 GVA. The cost of funding the allocation shortfall under the EC binary scenario in Phase

IV, for the baseline carbon price, is over £5m. Under the EC IA tiered scenario, the sector would have additional costs of £8.8m; while under the UK/FR proposal costs would be £6.7m to purchase 264,000 permits to fund the under-allocation of the sector.

- 3 Using the PRIMES projected prices the cost to the sector in Phase III is £0.8m. In Phase IV, under the EC binary scenario the cost of under allocation to the ceramic tiles and flags sector is £4m, approx. 4% 2012 GVA. The costs faced by the sector are higher under both tiered scenarios, UK/FR and EC IA, with values of £6.7m and £7.3m respectively.
- 4 Assuming a high ETS price, the costs for the sector would amount to over £2.2m by 2020. In Phase IV, under the EC binary scenario additional costs potentially amount to £14.8m. Under the UK/FR tiered scenario, costs to the ceramic tiles and flags sector would be £20.5m; while the EC IA scenario would be almost £27m.

Figure A.24 Extent and value of ETS permit over- and under-allocation in the ceramic tiles & flags sector between 2005-2020, under different price projections

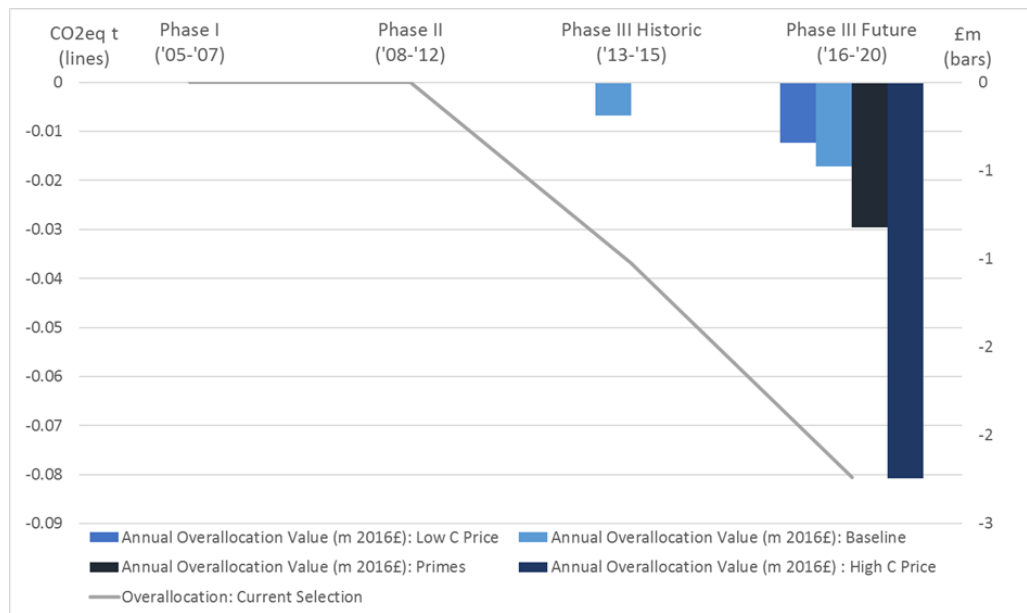
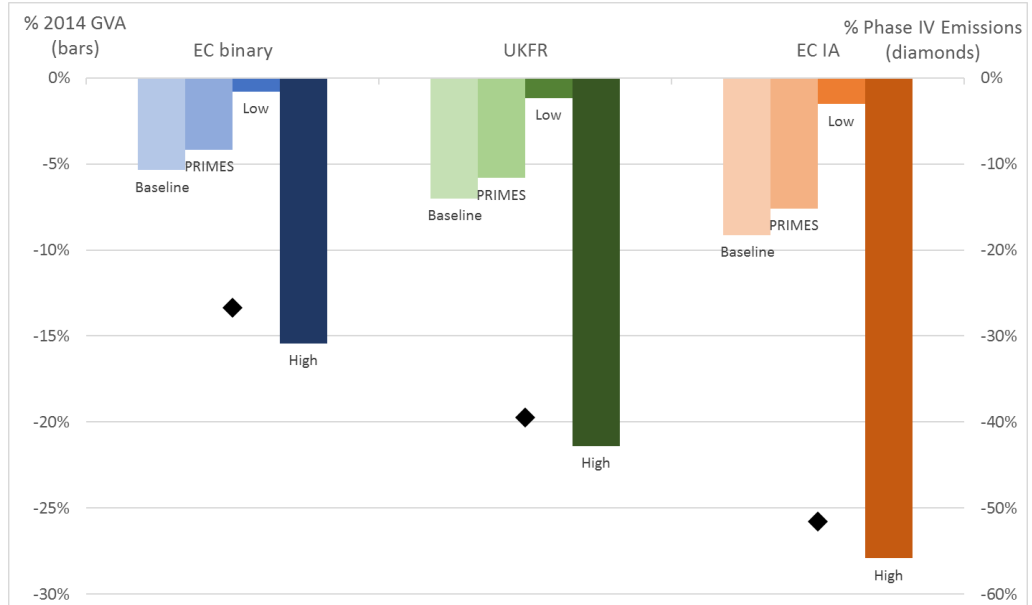


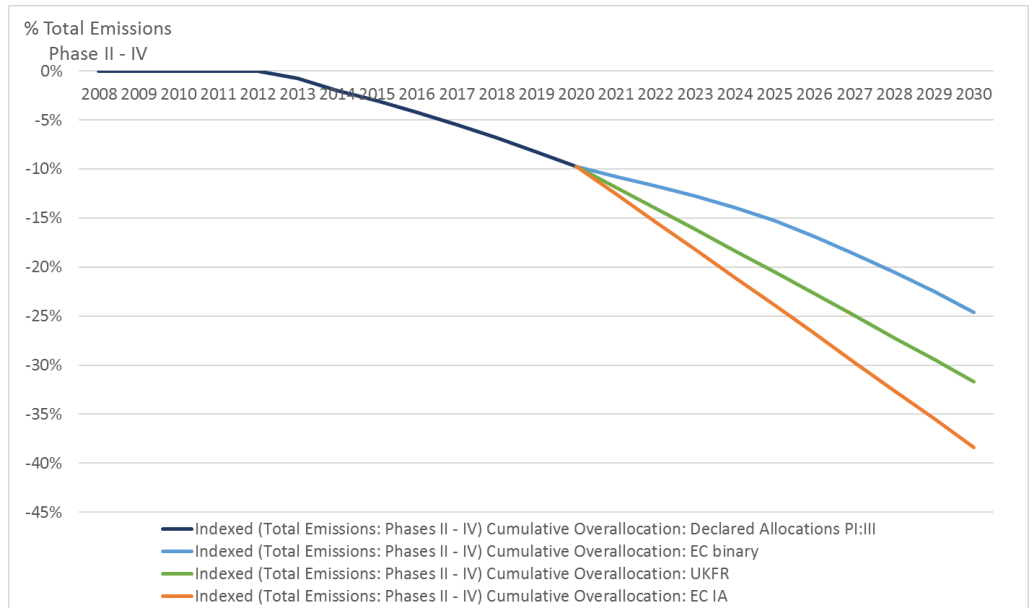
Figure A.25 Value of ETS permit under-allocation in the ceramic tiles & flags sector in Phase IV, under different price projections and different carbon leakage treatment scenarios, and its relative size to 2014 GVA (bars) and emissions (diamonds)



The ceramic tiles sector is in the medium risk tier in the UK/FR proposal and the low risk tier in the EC IA proposal classifications. The most generous scenario is the EC binary scenario; although even under this scenario the sector is likely to receive an under-allocation of permits. The least generous scenario is the EC/IA proposal, where installations receive only 60% of their benchmarks. The UK/FR scenario is more favourable at up to 75% of the benchmarks for free.

The sector is affected by under-allocation going forward, and this is not mitigated by the possibility of having banked over-allocation in previous phases, given that these installations only joined the EU ETS in 2013.

Figure A.26 Cumulative overallocation in the ceramic tiles & flags sector under full banking

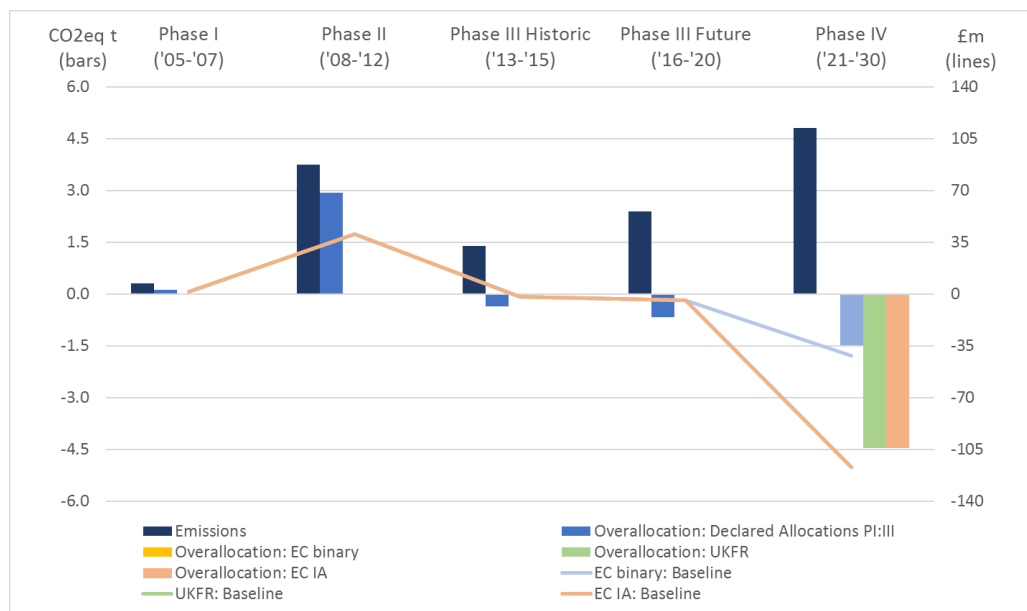


E.8 Findings for the Ceramic Bricks and Construction Products Sector

The ceramic bricks and construction products sector is different from each of the other sectors in this analysis because it has a carbon leakage indicator less than the EC binary limit of 0.2. The proposal does feature a proviso, however, that qualitative assessment of sectors with a carbon leakage indicator of greater than 0.12 can place a sector on the carbon leakage list. The ceramic bricks industry was judged, by this type of mechanism, to be at risk of carbon leakage for Phase III. This analysis therefore assumes that the sector will retain this status into Phase IV. The result, however, is that the tiered approaches are significantly less generous to the ceramic bricks sector, compared to the binary approach.

In Phase I of the EU ETS, the ceramic bricks sector’s allocation was 110,000 tonnes greater than verified emissions. In Phase II (2008-2012) there was a permit overallocation of almost 3m tonnes of CO₂e, potentially of £40m value. Phase III historic emissions exceeded allocation by 350,000 tonnes. Going forward, for Phase III, a deficit of allowances is likely (675,000 tonnes), assuming constant production and emissions. Phase IV (2020-2030) will see a greater deficit of 1.5m-4.5m tonnes of CO₂e, with the tiered approaches yielding the same outcome.

Figure A.27 Emissions, extent and value of ETS permit over- and under-allocation in the ceramic bricks and construction products sector between 2005-2030, baseline prices under different Phase IV scenarios



Analysing the value of future ETS permit deficits, four ETS price projections were used as set out above. For each of the scenarios, all benchmark calculations were reduced by 7.5% between 2021 and 2025, and 10%

between 2026 and 2030, based on 2008 (see Figure A.28 for Phase III and Figure A.29 for Phase IV).

- 1 Assuming a low ETS price, the costs for the ceramic bricks sector in the remainder of Phase III would total £3m. Under a low ETS price and the EC binary scenario the sector would face the least cost in Phase IV, at £6m. Calculating the tiered proposals, the sector would face the higher cost of £19m.
- 2 Under the baseline carbon price scenario, the cost of under-allocation for the remainder of Phase III is £4m, approx. 1.5% 2014 GVA. The cost under the EC binary scenario in Phase IV is over £40m, approx. 15% of 2012 GVA. Under the tiered scenarios, the sector would have additional costs of £117m to cover 45m tonnes of under-allocation; approx. 44% of 2014 GVA.
- 3 Using the PRIMES projected prices the cost to the sector in Phase III is £7m. In Phase IV, under the EC binary scenario the cost of under-allocation to the sector is £33m. Costs are higher under the tiered scenarios at £96m.
- 4 Assuming a high ETS price, the costs for the cement sector would amount to over £19m by 2020. For Phase IV, costs under the EC binary scenario would amount to £121m. Under the tiered scenarios, the under-allocation would have a potential cost of £353m.

Figure A.28 Extent and value of ETS permit over- and under-allocation in the ceramic bricks and construction products sector between 2005-2020, under different price projections

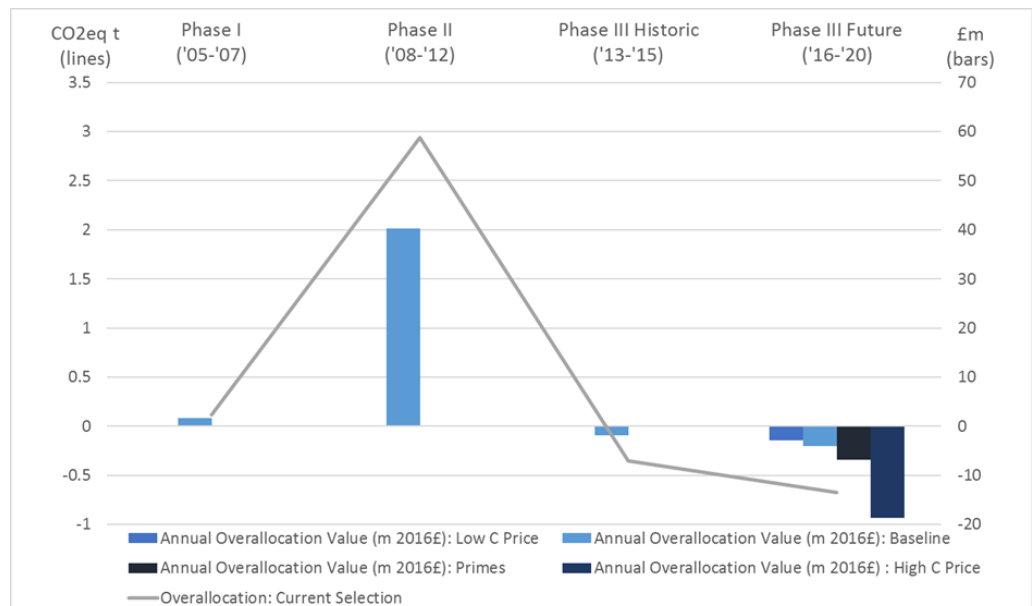
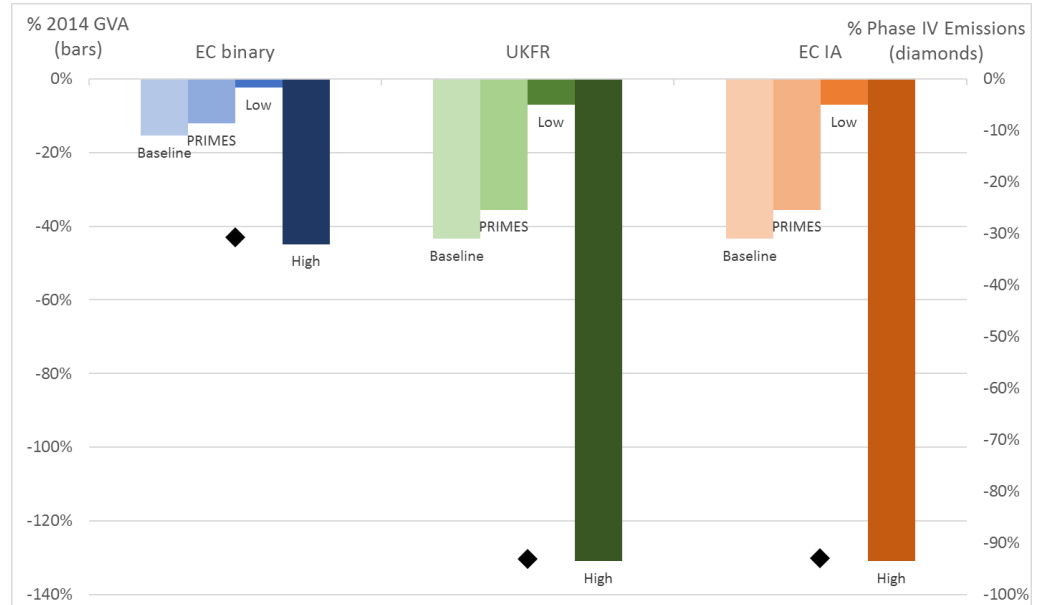


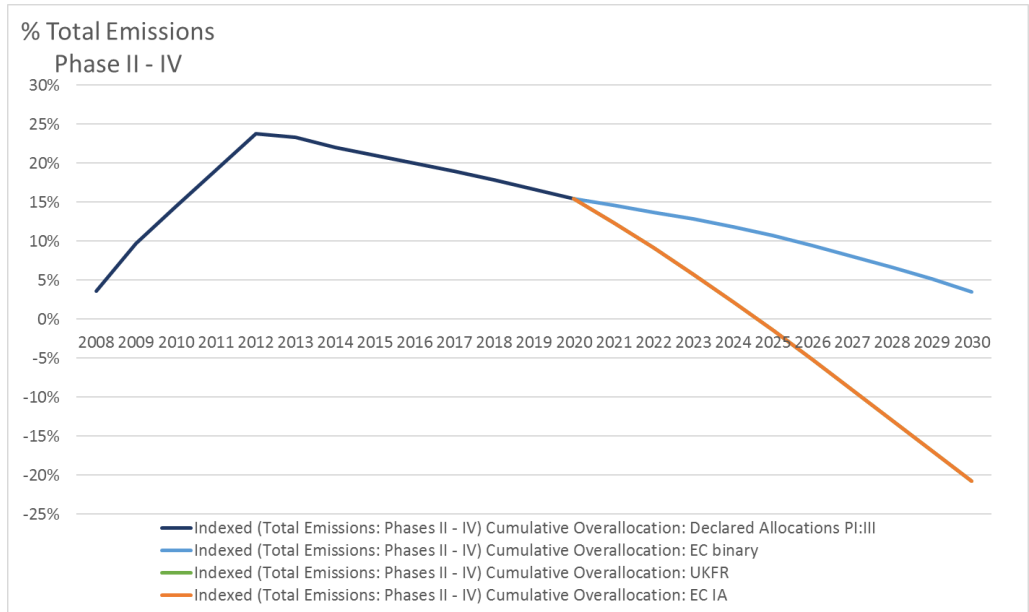
Figure A.29 Value of ETS permit under-allocation in the ceramic bricks and construction products sector in Phase IV, under different price projections and different carbon leakage treatment scenarios, and its relative size to 2014 GVA (bars) and emissions (diamonds)



The sector is assumed to be included in the ‘at risk’ list for the EC binary proposal, and would therefore receive up to 100% of benchmark as free allocations; although the CSCF is triggered. The sector is, however, below the threshold to be on the low risk tier for both tiered proposals and therefore receives an average of 9% free allocations across Phase IV. The value of the under-allocation is likely to be significant under any tiered proposal.

Assuming full banking of unused allowances, the sector’s overallocation would cover its projected deficit under the EC binary proposal. The results are markedly different for the tiered proposals: the sector would be under-allocated from 2025 and under-allocation may be 20% of total emissions across Phases II-IV by 2030.

Figure A.30 Cumulative overallocation in the ceramic bricks and construction products sector under full banking



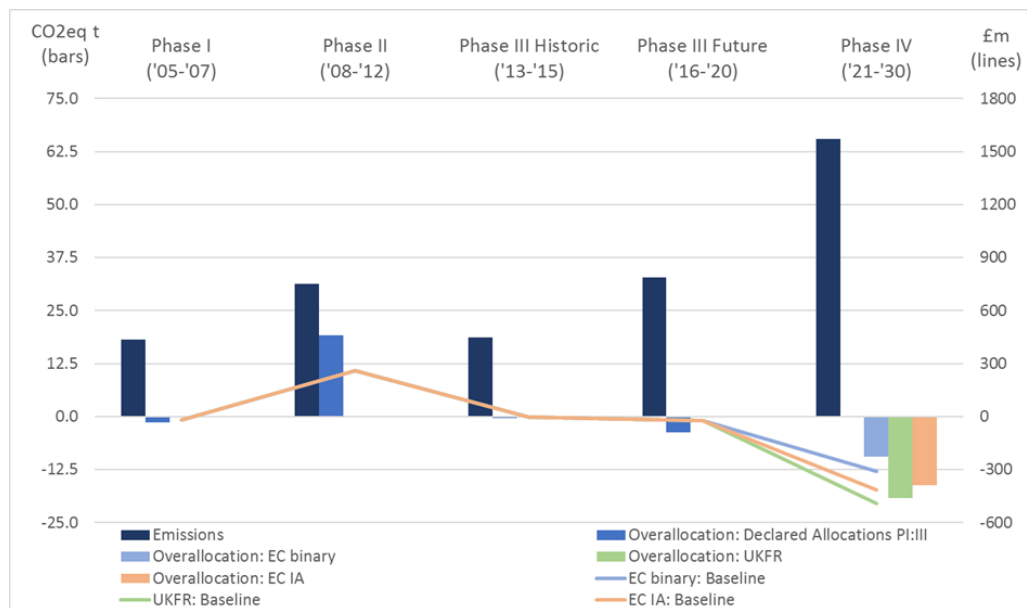
E.9 Findings for the Cement Sector

In Phase I of the EU ETS (2005-2007), the cement sector's allocation of permits was over 1.3m tonnes lower than its verified emissions; potentially costing £19m for the sector's installations. In Phase II (2008-2012) there was a permit overallocation of 19m tonnes of CO₂e of £260m value. Phase III historic emissions closely matched the sector's allocation.

In Phase II the value of the cement sector's over-allocation was substantial at 145% of 2012 GVA. However, in Phase III up to 2016, under-allocation has been less than 2% of 2012 GVA. Up to 2020, under the different price projections, the cement sector's under-allocation ranges from 9% to 62% of 2012 GVA.

Going forward, for Phase III, a deficit of allowances is likely (3.7m tonnes), assuming constant production and emissions. Phase IV (2020-2030) will see a greater deficit of 9.5m-19m tonnes of CO₂e, depending on the policy chosen.

Figure A.31 Emissions, extent and value of ETS permit over- and under-allocation in the cement sector between 2005-2030, baseline prices under different Phase IV scenarios



Analysing the value of future ETS permit deficits, four ETS price projections were used as set out above. For all approaches, all benchmark calculations were reduced by 7.5% between 2021 and 2025, and 10% between 2026 and 2030, based on 2008 (see Figure A.32 for Phase III and Figure A.33 for Phase IV).

- 1 Assuming a low ETS price, the costs for the cement sector in the remainder of Phase III would amount to £16m by 2020. Under a low ETS price and the EC binary scenario the UK cement sector would face the least cost in Phase IV, at £40m, to pay for the 9.5 CO₂eq t under-allocation. Calculating the tiered proposals, the sector would have to pay significant figures of £80m and £70m under the UK/FR and EC IA scenarios respectively.

- 2 Under the baseline carbon price scenario, the cost of under-allocation for the remainder of Phase III is £23m. The cost under the EC binary scenario in Phase IV, for the baseline carbon price, is over £310m, approx. 175% of 2012 GVA. Under the EC IA tiered scenario, the sector would have additional costs of £415m to cover 16m tonnes of under-allocation. While under the UK FR proposal, costs would be £490m to cover 19m permits to fund the under-allocation of the sector.
- 3 Using the PRIMES projected prices the cost to the sector in Phase III is £40m. In Phase IV, under the EC binary scenario the cost of under allocation to the cement sector is £225m. Costs are higher under both tiered scenarios, EC IA and UK/FR, with values £340m and £405m respectively.
- 4 Assuming a high ETS price, the costs for the cement sector would amount to over £110m by 2020, approx. 62% of 2012 GVA. In Phase IV, under the EC binary scenario the UK cement sector would have additional costs of £850m. Under the EC IA tiered scenario, costs would be £1.25bn; while the UK/FR scenario would be the highest cost, at over £1.5bn.

Figure A.32 Extent and value of ETS permit over- and under-allocation in the cement sector between 2005-2020, under different price projections

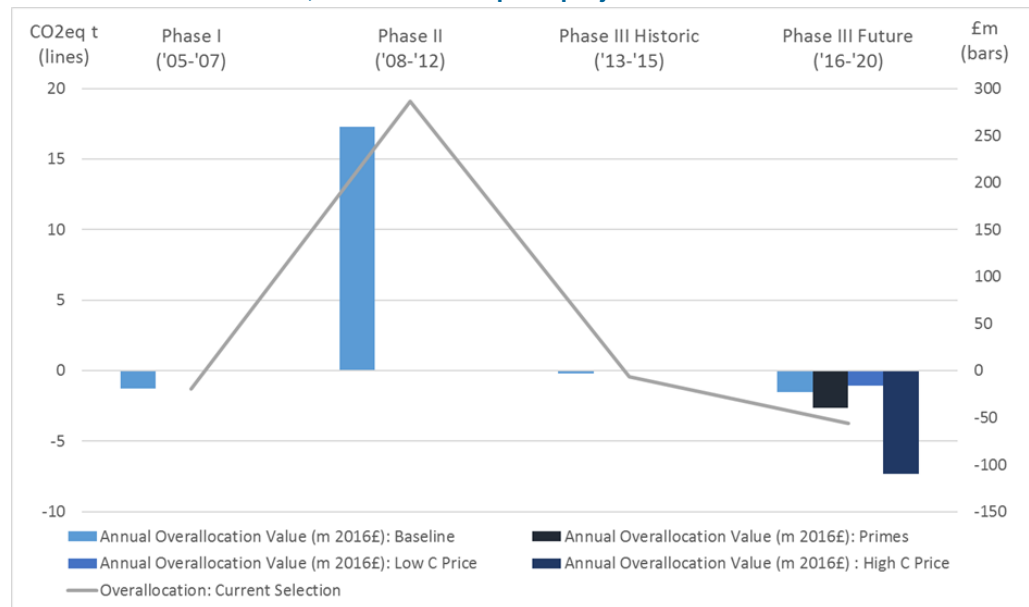
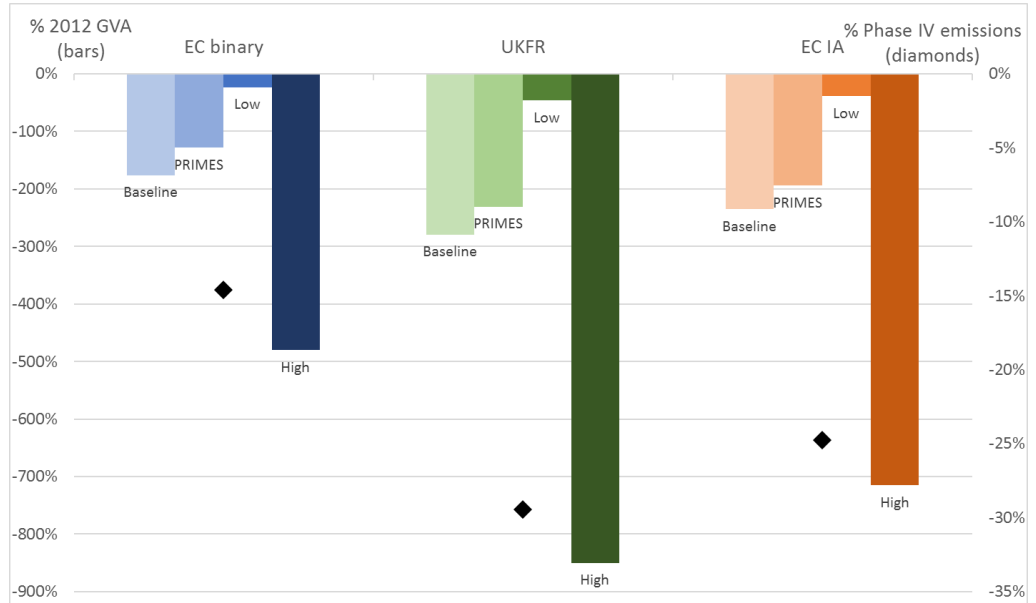


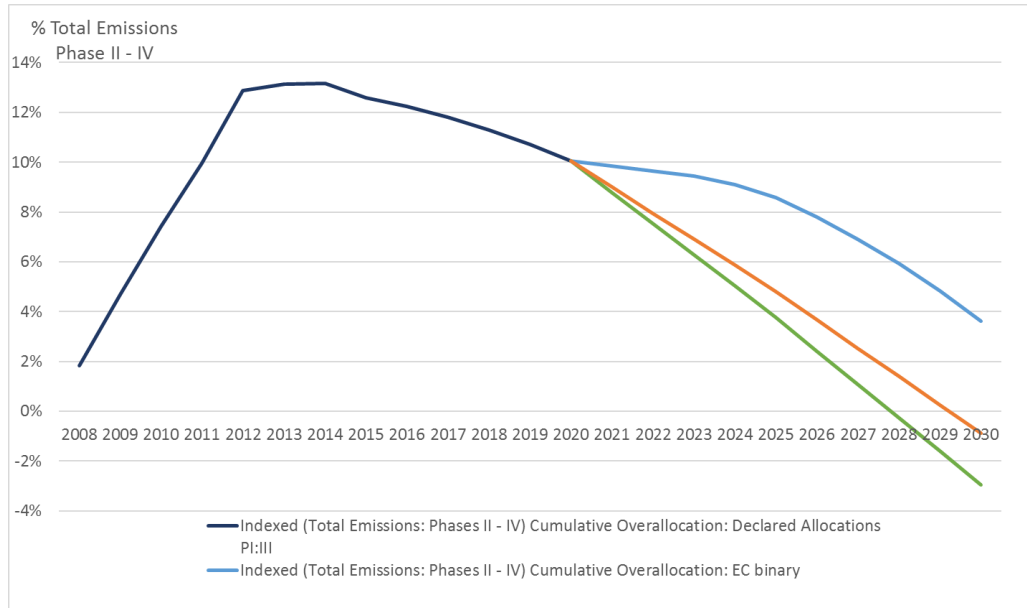
Figure A.33 Value of ETS permit under-allocation in the cement sector in Phase IV, under different price projections and different carbon leakage treatment scenarios, and its relative size to 2014 GVA (bars) and emissions (diamonds)



The cement sector is in the medium risk tier in both the tiered UK/FR and EC IA proposal classifications. The most generous scenario, is the EC binary scenario. However, even under this scenario the sector is likely to receive a significant under allocation. The tiered proposals yield similar results, but the most stringent is the UK/FR scenario where installations receive only 75% of their benchmarks in the medium tier (as opposed to 80% in EC IA). The value of the under-allocation is likely to be significant with regards to the profitability of the cement sector during Phase IV; ranging from 175% to 280% of 2012 GVA across Phase IV scenarios under baseline carbon price conditions.

Assuming full banking of unused allowances, the cement sector’s overallocation would cover its projected deficit under the EC binary proposal, while under the UK/FR and EC IA proposal it would be under-allocated from 2028 and 2029 respectively.

Figure A.34 Cumulative overallocation in the cement sector under full banking



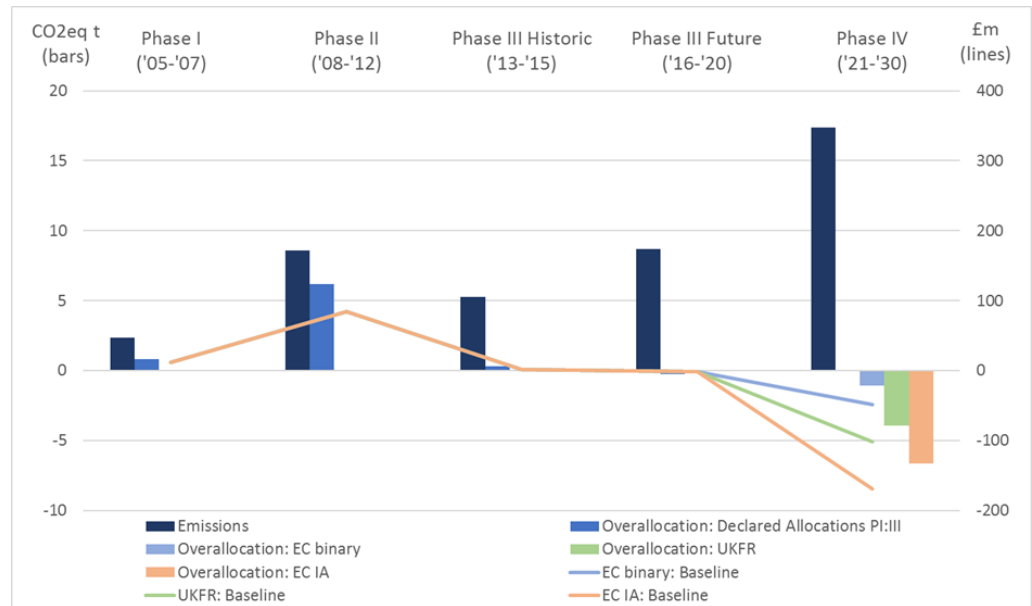
E.10 Findings for the Lime & Plaster Sector

In Phase I (2005-2007), the trial period of the EU ETS, the lime & plaster sector’s allocation was 840,000 higher than its verified emissions. In Phase II (2008-2012) the permit over-allocation was much more significant, 6.2 million tonnes of CO2e with a £85m value. Phase III historic emissions closely matched the sector’s allocation, most probably due to the right operation of the central allocation mechanism.

In Phases I and II the value of the lime & plaster sector’s overallocation was substantial at 40% and almost 290% of its 2012 GVA respectively. However, in Phase III up to 2016 it has been less than 5%. Up to 2020, under the different price projections, the lime & plaster sector’s under-allocation ranges from 4% to 32% of 2012 GVA.

In future for Phase IV a significant deficit of allowances is likely, assuming constant production and emissions intensity. Phase IV (2020-2030) will see a greater deficit of 1.1 – 6.6 million tonnes of CO2e, depending on the policy scenario chosen for Phase IV implementation.

Figure A.35 Emissions, extent and value of ETS permit over- and under-allocation in the lime & plaster sector between 2005-2030, baseline prices under different Phase IV scenarios



Analysing the value of future ETS permit deficits, four ETS price projections were used as set out above. For each scenario, all benchmark calculations were reduced by 7.5% between 2021 and 2025, and 10% between 2026 and 2030, on 2008 (see Figure A.36 for Phase III and

Figure A.37 for Phase IV).

- 1 Assuming a low ETS price, the costs for the lime & plaster sector in the remainder of Phase III would amount to £1m by 2020. Under a low ETS price and the EC binary scenario the UK lime & plaster sector would face a modest cost in Phase IV, of £5m, to pay for the 1.1 million under-allocation. Calculating the tiered proposals, the sector would have to pay significant figures of £17m and £28m under UK/FR and EC IA tiered proposals respectively.
- 2 Under the baseline carbon price scenario, the cost of under-allocation for the remainder of Phase III is £1.6m, 6% approx. 2012 GVA. The cost of 1.1 million permits to fund the allocation shortfall under the EC binary scenario in Phase IV (for the baseline carbon price) is over £48m, approx. 160% of 2012 GVA. Under the EC IA tiered scenario, the sector would have additional costs of £100m; while under the EC IA proposal, costs would be £170m.
- 3 Using the PRIMES projected prices the cost to the sector in Phase III is £3m. In Phase IV, under the EC binary scenario the cost of under-allocation to the UK lime & plaster sector is over £30m. Costs are higher under both tiered scenarios, UK/FR & EC IA, with of value of £83m and £140m respectively.
- 4 Assuming a high ETS price, the cost for the lime & plaster sector would amount to over £9m by 2020. In Phase IV, under the EC binary scenario, the UK lime & plaster sector would have additional costs of £117m. While under the UK/FR & EC IA tiered scenarios, costs would be £307m and £515m respectively.

Figure A.36 Extent and value of ETS permit over- and under-allocation in the lime & plaster sector between 2005-2020, under different price projections

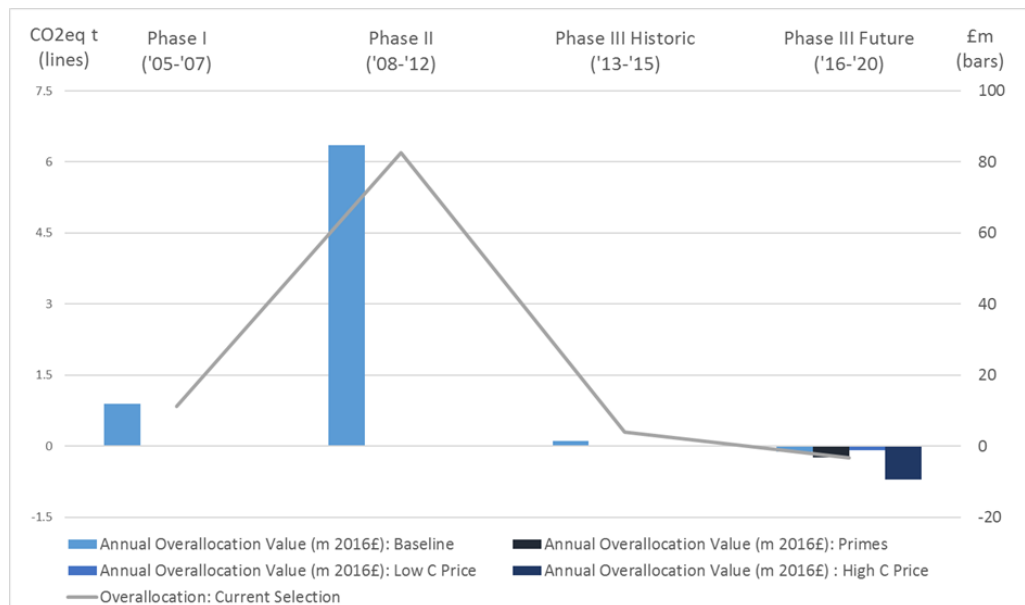
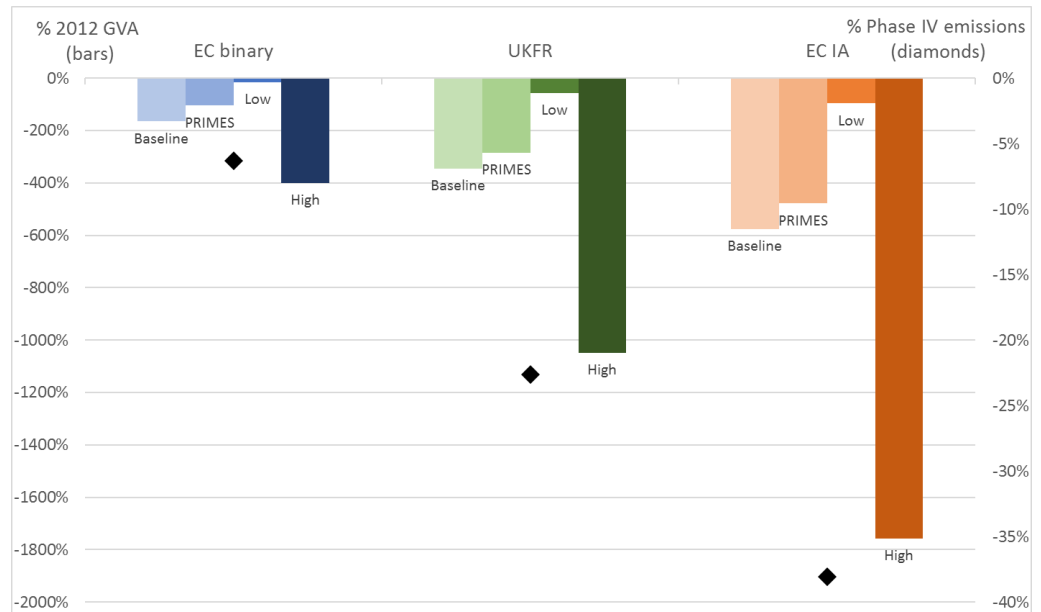


Figure A.37 Value of ETS permit under-allocation in the lime & plaster sector in Phase IV, under different price projections and different carbon leakage treatment scenarios, and its relative size to 2014 GVA (bars) and emissions (diamonds)



The lime & plaster sector is in the medium risk tier in the UK/FR proposal classifications, but in the low risk tier in the EC IA classifications. The most generous scenario is the EC binary scenario; but even under this scenario the sector is likely to receive a significant under allocation. The most stringent scenario is the EC IA scenario where installations receive only 50% of their benchmarks: the value of the under-allocation could be crippling to the profitability of the sector, reaching almost six times 2012 GVA under baseline carbon price conditions.

Assuming full banking of unused allowances, the lime & plaster sector's over-allocation would cover its projected deficit almost entirely until the end of Phase IV, it would be in deficit only in 2030 under the EC IA proposal.

Figure A.38 Cumulative overallocation in the lime & plaster sector under full banking

