Managing competitiveness risks of low-carbon policies

Committee on Climate Change | April 2013

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Preface

The Committee on Climate Change (the Committee) is an independent statutory body which was established under the Climate Change Act (2008) to advise UK and Devolved Administration governments on setting and meeting carbon budgets, and preparing for climate change.

Setting carbon budgets

In December 2008 we published our first report, 'Building a low-carbon economy – the UK's contribution to tackling climate change', containing our advice on the level of the first three carbon budgets and the 2050 target. This advice was accepted by the Government and legislated by Parliament in May 2009. In December 2010, we set out our advice on the fourth carbon budget, covering the period 2023-27, as required under Section 4 of the Climate Change Act. The fourth carbon budget was legislated in June 2011 at the level that we recommended.

Progress meeting carbon budgets

The Climate Change Act requires that we report annually to Parliament on progress meeting carbon budgets. We have published four progress reports in October 2009, June 2010, June 2011 and June 2012.

Advice requested by Government

We provide ad hoc advice in response to requests by the Government and the devolved administrations. Under a process set out in the Climate Change Act, we have advised on reducing UK aviation emissions, Scottish emissions reduction targets, UK support for low-carbon technology innovation, design of the Carbon Reduction Commitment, renewable energy ambition, bioenergy and the role of local authorities. In September 2010, July 2011 and July 2012, we published advice on adaptation, assessing how well prepared the UK is to deal with the impacts of climate change.

This report

This technical report sets out the detailed analysis of the competitiveness risks and opportunities associated with fourth carbon budget measures. It supports our advice published in April 2013 on the UK's carbon footprint and competitiveness: 'Reducing the UK's carbon footprint and managing competitiveness risks'.

Acknowledgements

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Other members of the Secretariat that contributed to the report: Alice Barrs, Tara Barker, David Joffe, Swati Khare-Zodgekar, Jo McMenamin, Laura McNaught, Joanna Ptak and Stephen Smith.

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A wide range of stakeholders who engaged with us, provided advice, attended our expert workshops, or met with the Committee bilaterally.

Contents

The Committee

The Rt. Hon John Gummer, Lord Deben, Chairman
The Rt. Hon John Gummer, Lord Deben established and chairs Sancroft, a Corporate Responsibility consultancy working with blue-chip companies around the world on environmental, social and ethical issues. He was the longest serving Secretary of State for the Environment the UK has ever had. His experience as an international negotiator has earned him worldwide respect both in the business community and among environmentalists. He has consistently championed an identity between environmental concerns and business sense.

David Kennedy (Chief Executive)
David Kennedy is the Chief Executive of the Committee on Climate Change. Previously he worked on energy strategy and investment at the World Bank, and the design of infrastructure investment projects at the European Bank for Reconstruction and Development. He has a PhD in economics from the London School of Economics.

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Paul is the director of the Institute for Fiscal Studies. He has worked on the economics of public policy throughout his career. Paul has been chief economist at the Department for Education and director of public spending in HM Treasury, where he had particular responsibility for environment (including climate change), transport and public sector pay and pensions. Between 2004 and 2007 Paul was deputy head of the Government Economic Service. He has also served on the council of the Economic and Social Research Council.

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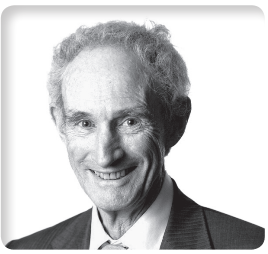
Professor Dame Julia King DBE FREng Vice-Chancellor of Aston University. She led the 'King Review' for HM Treasury in 2007-8 on decarbonising road transport. She was formerly Director of Advanced Engineering for the Rolls-Royce industrial businesses, as well as holding senior posts in the marine and aerospace businesses. Julia is one of the UK's Business Ambassadors, supporting UK companies and inward investment in low-carbon technologies. She is an NED of the Green Investment Bank, and a member of the Airports Commission.

Lord John Krebs
Professor Lord Krebs Kt FRS, is currently Principal of Jesus College Oxford. Previously, he held posts at the University of British Columbia, the University of Wales, and Oxford, where he was lecturer in Zoology, 1976-88, and Royal Society Research Professor, 1988-2005. From 1994-1999, he was Chief Executive of the Natural Environment Research Council and, from 2000-2005, Chairman of the Food Standards Agency. He is a member of the U.S. National Academy of Sciences. He is chairman of the House of Lords Science & Technology Select Committee.



Lord Robert May
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Professor Jim Skea is Research Councils UK Energy Strategy Fellow and Professor of Sustainable Energy at Imperial College London. He was previously Research Director at the UK Energy Research Centre (UKERC) and Director of the Policy Studies Institute (PSI). He led the launch of the Low Carbon Vehicle Partnership and was Director of the Economic and Social Research Council's Global Environmental Change Programme.

Introduction and key messages

This report sets out new analysis of competitiveness risks associated with the first four carbon budgets, building on analysis in our 2010 report[1] recommending the level of the fourth carbon budget. Competitiveness risks could arise if carbon budgets and the policies used to achieve them disadvantage specific sectors in international competition, harming profits and employment and potentially driving the location of production to other countries. These risks could, if not addressed, disadvantage industry without reducing the UK's carbon footprint because of carbon leakage.

Competitiveness risks are a particular issue for energy-intensive industries. The risks exist because of carbon policies which increase costs of burning fossil fuels ('direct emissions') and consuming electricity ('indirect emissions'). Our approach is to focus analysis on those sectors most at risk. We address the extent to which currently legislated carbon budgets, including the fourth carbon budget, present particular risks to these sectors, together with the measures needed to mitigate this risk. We also address specific issues in agriculture, given the highly traded nature of some farming products.

Measures to alleviate these risks may be justified in energy-intensive sectors to preserve profits or wages relating to investments made before the policies were introduced; to stop existing industry relocating to other countries; and to encourage new investment in these sectors.

It is important to note that, where required, these supporting measures should be transitional on the path to a global deal which would, over time, ensure a level playing field and reduce the need for support. This transition is important in changing consumer price signals to encourage a shift away from high carbon goods. Furthermore, there are opportunities as well as competitiveness risks associated with the move to a low-carbon economy (e.g. new markets for low-carbon technologies).

We focus on competitiveness impacts in a carbon-constrained world and develop alternative scenarios for how quickly this constraint binds different countries. We differentiate between impacts to 2020 which result from current policies and require action, and those to 2030 which relate largely to measures not yet in place and which are more uncertain.

The wider context of this report is our review of the fourth carbon budget, on which we will be providing further advice by the end of 2013. The analysis in the report will help inform us whether the level at which the fourth budget is currently legislated remains appropriate based on consideration of the competitiveness risks. The review later this year will consider progress towards a global deal, drawing out implications for appropriate ambition in the fourth carbon budget.

1 CCC (2010) *The Fourth Carbon Budget – reducing emissions through the 2020s* available at http://www.theccc.org.uk

The key messages from our analysis are:

- **Competitiveness risks of carbon budgets for industry**
  - **Direct emissions.** Costs and competitiveness risks associated with measures to reduce direct emissions (i.e. related to burning of fossil fuels) in currently legislated carbon budgets are manageable. Continued support in the EU Emission Trading System (EU ETS) for industries subject to international competition may be required through the 2020s, dependent on progress towards a global deal.
  - **Electricity price impacts to 2020.** Competitiveness risks to electro-intensive industries of low-carbon policies relate to current Government policies funded under the levy control framework. We estimate that possible profit impacts are commensurate with support under already announced policies to address these impacts. This could increase energy bills by around £5 for the typical household in 2020.
  - **Electricity price impacts from 2020 to 2030.** These are more uncertain than impacts to 2020, particularly due to uncertainty about low-carbon policies in other countries. However, in a carbon-constrained world, our analysis suggests that required support would decline over time as carbon policies increase in other countries.
- **Competitiveness risks of carbon budgets for agriculture**
  - While risks associated with direct on-farm abatement are expected to be low, rising electricity prices could impact the competitive position of some electro-intensive farming activities (e.g. pigs, poultry and dairy). Opportunities to offset the impact of rising electricity prices through energy efficiency improvement, use of renewable energy and other innovations should be further assessed.
- **Opportunities from being on the least-cost path to 2050**
  - Early investment to decarbonise the power sector results in higher electricity prices in the short-term. But compared to the alternative conventional fossil fuel based system, we project lower prices for a low-carbon power system in the medium-term as carbon prices rise.
  - A move to a low-carbon economy will create new markets for products from the energy-intensive sectors, both at home and abroad. Our analysis suggests there could be higher demand for some energy-intensive products supplied to the power and heat sectors in the UK over the period 2013-2020 compared with a conventional energy scenario. The UK has a comparative advantage in some key low-carbon technologies, parts of heavy engineering and construction as well some energy-intensive sectors such as parts of chemicals and plastics, which could contribute to these supply chains. Some energy-intensive industries have developed new low-carbon technologies and processes which makes them well placed to compete in new markets on the path to a low-carbon world.

Looking forward to the review of the fourth carbon budget, our analysis implies that the competitiveness risks associated with low-carbon measures to reduce direct emissions are limited and manageable. Electricity price impacts for electro-intensive industries are due mainly to policies to which the Government has already committed for investment in the period to 2020, and within the range of support associated with policies already announced by the Government. Incremental impacts due to the fourth carbon budget are therefore limited given the expected reduction in costs of low-carbon technologies in this period and rising carbon and electricity prices in other countries.

Our analysis focuses on a carbon-constrained world on the path to achieving the global climate objective[2]. If other countries were to depart significantly from this course, an assessment of global ambition and therefore ambition in UK carbon budgets would be required, rather than of competitiveness impacts *per se*.

We set out our analysis of this report in three sections:

1. Competitiveness benefits from being on the least-cost path to meeting the 2050 target
2. Industries impacted by carbon policies
3. Competitiveness risks for agriculture associated with the fourth carbon budget

2 That is, consistent with a global climate objective of 2°C by 2050 (i.e. early peaking of global emissions with a 50% cut in 2050, to keep central estimates of climate change close to 2°C and limit the likelihood of very dangerous climate change.

Chapter 1: Competitiveness benefits from being on the least-cost path to meeting the 2050 target

There are opportunities for energy-intensive industries to benefit from the early transition to a low-carbon economy:

- Lower medium to long-term electricity prices. We have previously projected[1] wholesale electricity prices to 2050 in a gas-based world and a low-carbon world incorporating carbon prices consistent with meeting carbon budgets (key assumptions underpinning these scenarios are shown in Table 1.1).
- Electricity prices in a gas-based world and a low-carbon world are the same up to 2020, due to investments already committed to in that period arising largely from the renewable energy target and the required replacement of existing nuclear fleet.
  - In the 2020s, our analysis suggests that investment to decarbonise the power sector results in slightly higher electricity prices in the low-carbon scenario compared with investment in predominantly gas generation.
  - Beyond 2030, electricity prices in the low-carbon scenario are lower than those in a system relying on large amounts of unabated gas-fired generation (Figure 1.1). This reflects falling costs of low-carbon technologies, in contrast to rising generation costs in a gas-based scenario as a result of rising carbon prices (in line with DECC central assumptions).

Therefore, we project relatively low prices for a low-carbon power system in the medium and longer-term compared with the alternative conventional system based on fossil fuels subject to a rising carbon price. While the low-carbon scenario results in a small competitiveness loss in the short-term compared with a largely gas-based investment strategy, this is offset by a larger competitiveness benefit in the medium and longer-term.

Table 1.1: Key assumptions underpinning wholesale electricity price projections

	Low-carbon scenario	Gas based scenario
To 2020	Price impacts reflect the costs of Renewables Obligation (RO), Feed-in-Tariff (FiT), increasing carbon price, Contract for Difference (CfD) payments, cost of intermittency and smart meters. Costs are in line with the Levy Control Framework.	

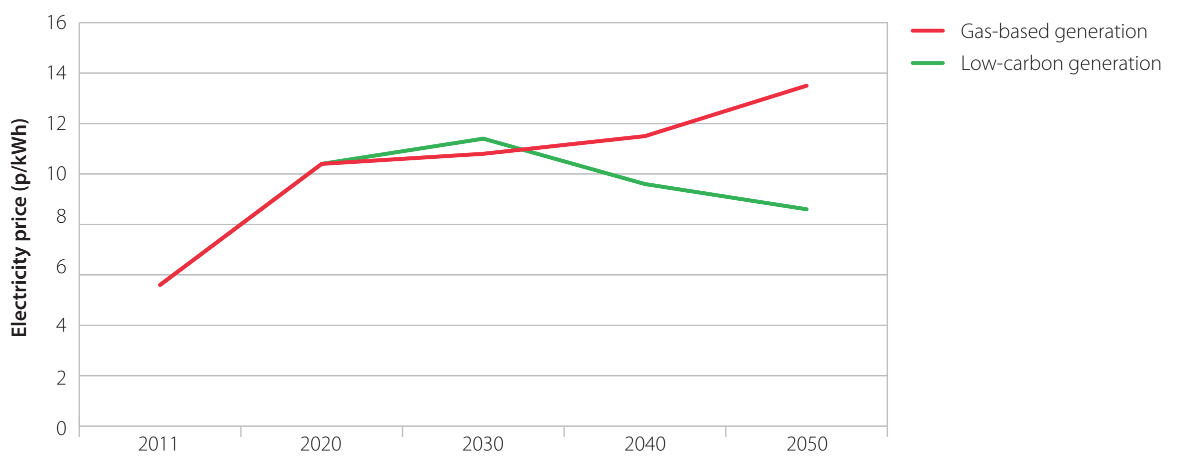
1 CCC (2012) *Energy prices and bills – impacts of meeting carbon budgets* available at http://www.theccc.org.uk/

Table 1.1: Key assumptions underpinning wholesale electricity price projections

2020-2030	Key drivers are the costs of CfDs, carbon price, and higher system costs due to intermittency. Rising costs are partially offset by savings due to end of support for generation under RO and FiTs	Gas generation cost around 6.5p/kWh in line with DECC central fossil fuel price assumptions (70p/therm). No additional CfD & intermittency costs. Carbon price rises from around £30/tCO_2 to £70/tCO_2 in 2030, in line with the Carbon Price Floor (CPF). Partially offset by savings due to end of support for RO and FiTs.
2030-2050	Declining cost of renewable and other low-carbon generation due to learning. Electricity price is a weighted average of levelised costs of different plants according to vintage.	Growth in gas reserves keeps pace with demand so no change in wholesale gas prices. Carbon price rises as in Government carbon values to £135/tCO_2 in 2040 and £200/tCO_2 in 2050. Retiring onshore wind plants are replaced, and some new nuclear is built.

Source: CCC calculations
Note: The definition of wholesale electricity prices here is the cost of generation electricity plus transfer payments to fund low-carbon generation and wider system costs associated with intermittent renewables. Excludes other factors that make up the retail price (e.g. network costs, supplier costs & margins, VAT). The retail price faced by industrial users will depend on their ability to negotiate lower wholesale prices through bargaining power, direct contracts with generators, and economies of scale in supply. Renewable costs estimates and learning in line with Mott MacDonald (2011) and the CCC Renewable Energy Review.

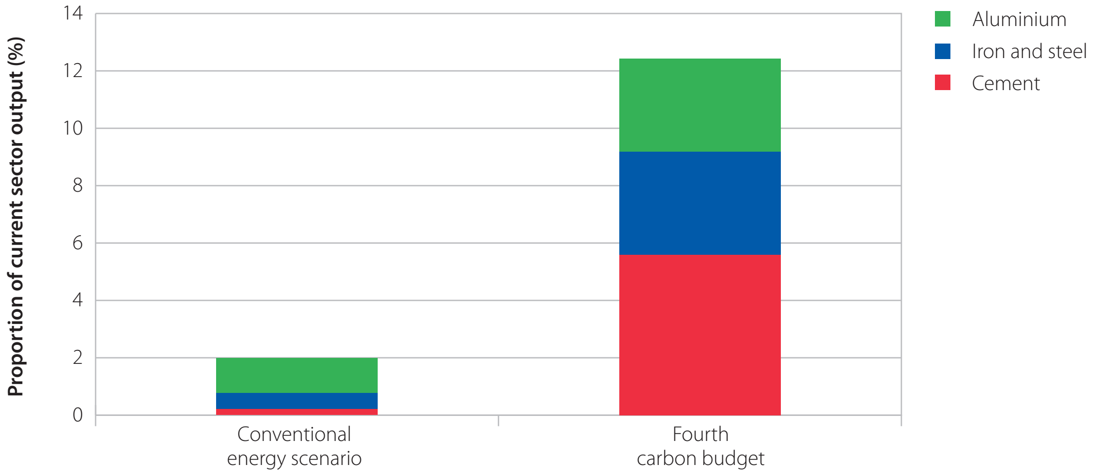
Figure 1.1: Industrial electricity prices in a low-carbon world versus a 'dash for gas' in the 2020s



Source: Ofgem and CCC calculations.
Notes: Chart shows wholesale electricity price, including transfer payments to fund low-carbon generation via the Renewables Obligation and Contracts for Difference, and wider systems costs associated with intermittent renewables (where relevant). The retail price faced by industrial users will depend on ability to negotiate lower wholesale prices through bargaining power, direct contracts with generators and economies of scale in supply.

- **New markets.** A move to a low-carbon economy will create new opportunities for energy-intensive industries in meeting demand for low-carbon technologies in domestic and export markets:
  - Our analysis suggests that there could be higher demand for some energy-intensive products supplied to the power and heat sectors in the UK over the period 2013-2030 compared with a conventional energy scenario (Figure 1.2). Most of this additional demand stems from the power sector, where low-carbon power sources (e.g. onshore and off-shore wind turbines, nuclear and CCS) which contain more embodied iron, steel and cement compared to conventional gas power plants.

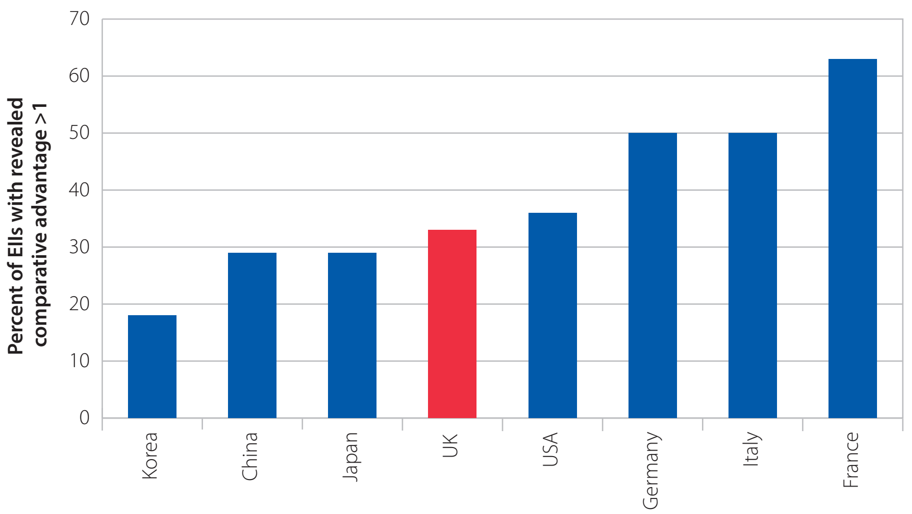
Figure 1.2: Annual material requirements for the power sector (2013-2030)



Source: CCC calculations based on model developed by Ricardo-AEA.
Notes: We compared material requirements for the power sector between 2013 and 2030 under a conventional energy scenario and under our scenarios for the fourth carbon budget. The conventional energy scenario reflects a gas-based system; the fourth carbon budget scenario reflects a portfolio of low-carbon technologies (i.e. on- and off-shore wind, nuclear, CCS, and some unabated gas). We combined these scenarios with data on embodied materials in different technologies (from our analysis of life-cycle emissions in Chapter 3). The chart shows the implied annual material requirements for each sector as a proportion of their current output (i.e. the cement requirement under a conventional energy scenario is less than 1% of current cement output; this rises to around 6% in a low-carbon scenario reflecting the additional cement needed for low-carbon technologies).

– Our 2010 Innovation Review identified key areas where the UK had developed significant capability and potential to develop a leadership role in international markets. The UK was well placed to take on a 'develop and deploy' strategy in offshore wind, marine, CCS for power, smart grids, aviation and electric vehicle technologies. Our analysis suggests that some energy-intensive sectors in the UK such as parts of chemicals, articles of concrete and cement and some non-metallic minerals, as well as aerospace, electronics and parts of heavy engineering and construction have a comparative advantage compared with key competitors (Figure 1.3). This makes these sectors well placed to contribute to the supply chain of these technologies.

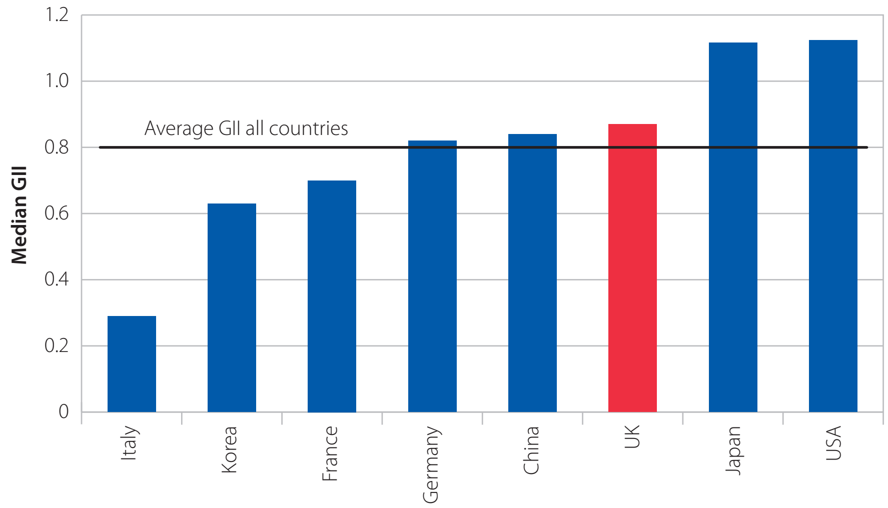
Figure 1.3: Share of UK energy intensive industry with a comparative advantage – cross country comparison



Source: CCC calculatons based on data provided in Fankhauser et al. (2012) *Who will win the green race? In search of environmental competitiveness and innovation* available at http://www2.lse.ac.uk/GranthamInstitute/publications/WorkingPapers/Papers/90-99/WP94-green-race-environmental-competitiveness-and-innovation.pdf

- **Innovative new technologies and processes.** The move to a low-carbon economy will involve innovative processes and technologies across a wide range of sectors and applications. Current low-carbon innovation activity (as measured by the Green Innovation Index (GII)) (Box 1.1) is a useful indicator of how a sector is positioned to take advantage of the move from conventional to lower-carbon production. Our analysis shows that some UK energy-intensive industries are well placed in terms of current green patenting activity and that on average UK energy-intensive industries have a higher GII than key competitors (Figure 1.4).

Figure 1.4: Median Green Innovation Index in energy-intensive industries



Source: CCC calculatons based on data provided in Fankhauser et al. (2012) op. cit.

Box 1.1: Green Innovation Index (GII)

The Green Innovation Index measures the ratio of green patents to total patenting activity in each country-sector, compared with the same ratio across all country-sectors in the sample. It is given by:

$$\frac{\text{Green patents (s,i) /all patents (s,i)}}{\sum_{s\,i} \text{green patents/ all patents (s,i)}}$$

For s sector and i country.

The index therefore measures how well placed particular sectors are in developing low-carbon innovation relative to innovation activity in that sector generally, and relative to other countries. Scores of GII>1 indicate a better than average performance on this measure, compared with other countries in the sample.

The definition of green patents used here relates to the Y0 class from the European Classification System (ECLA) which covers patents related to 'technologies or applications for mitigation or adaptation against climate change'. Whilst patent data are not a complete indicator of innovation activity, they are available at a highly disaggregated level (which allows us to identify specific innovations in green technologies across all firms, including smaller enterprises).

Source: Fankhauser et al. (2012) *Who will win the green race? In search of environmental competitiveness and innovation* available at http://www2.lse.ac.uk/GranthamInstitute/publications/WorkingPapers/Papers/90-99/WP94-green-race-environmental-competitiveness-and-innovation.pdf

– Parts of the energy-intensive industries that have a head start in green patenting activity include basic non-ferrous metals, refineries and parts of the rubber and chemicals sectors. There is a role for energy-intensive industries in developing new innovative low-carbon products such as low-temperature detergents, low-resistance tyres and lightweight materials in aircraft and cars. Examples of how some companies have benefitted from green innovation are shown in Table 1.2.

– Other sectors, such as parts of non-metallic minerals have undertaken little or no green innovation and these sectors may struggle to compete in the transition to a lower carbon economy.

The challenge is to design policy in a way that allows industry to benefit, while mitigating potential competitiveness risks in the near to medium-term due to the fact that some countries will have a less stringent climate change mitigation measures in this period.

Table 1.2: Case studies – companies benefitting from green innovation

Sector/Industry	Issue	Solution	Benefits
Magor Brewery, Newport, Wales	High energy and water usage led staff and management team to identify potential resource savings.	Company invested £1.4m in ideas and initiatives put forward by workforce.	The Magor plant reduced energy use by 47% and more than halved the amount of water required per litre of product, cutting emissions by 40% and re-couping its investment in 18 months.
WBC Automotives, Bristol	Concern about rising energy cost and improving green credentials.	With a Carbon Trust loan of £98k, it invested in new energy-efficient spray booths used to coat vehicles with paint and lacquer.	Achieved £70k pa savings in energy bills and operating costs and increased productivity from 14 to 18-20 cars sprayed per day.
Volvic-Danone, plastics used in bottles.	Reducing the carbon footprint of the Volvic brand.	Developed an innovative greener bottle made partially from sugarcane waste, which will contain 20% plant material, reducing the amount of non-renewable material needed to create the bottle. Uses dehydrated sugar cane waste – a by-product of sugar production.	Green bottle expected to have a 38% lower packaging carbon footprint and a 16% lower total lifecycle footprint than the previous bottle. In addition Volvic are reducing the weight of the current bottle which is expected to halve the carbon footprint.

Source: Carbon Trust Director report April 2011 *Putting sustainability at the heart of your business* available at http://www.director.co.uk/Content/pdfs/CarbonTrust_Apr11.pdf
TUC *Green workplaces case study* available at:
http://www.tuc.org.uk
http://www.danone.co.uk/news/media/volvic-greener-bottle.aspx

Chapter 2: Industries impacted by carbon policies

Industries face competitiveness risks from low-carbon policies through:

- Higher costs for firms in the UK that are not experienced by their competitors which may directly impact profits where costs cannot be passed on to higher prices.
- To the extent that costs are passed through, higher prices could lead to loss of export markets and displacement of domestic production by imports from existing or new facilities.
- Erosion of profit margins could lead to UK firms undertaking cost reduction measures elsewhere, for example by cutting wages or making redundancies or through reducing returns to shareholders.
- A longer period of lower profits could lead to offshoring and discourage future investment.

However, low-carbon policies have not caused significant offshoring to date. We explore this in more detail in our companion report[1] on the UK's carbon footprint.

Although a shift in relative prices away from high-carbon goods is desirable as all countries move towards a low-carbon economy, this presents a risk in the short-run where this process does not happen at the same pace across all countries and sectors.

We start with describing industries at risk and their contribution to the economy in terms of output, employment and their location within the UK.

We consider competitiveness impacts arising through direct and indirect carbon budget measures, with a focus on the impact of higher electricity prices affecting the most electro-intensive sectors. We undertake detailed analysis of the characteristics of the sectors most at risk and develop a simple modelling framework to assess the scale of the potential competitiveness distortions.

We then address the need for policy levers to mitigate these risks.

Economic and Environmental context

Manufacturing industry is an important source of GHG emissions. In 2011, industry accounted for 164 $MtCO_2$ (36%) of UK emissions, covering both direct and indirect emissions. Emissions in this sector are concentrated among energy-intensive sectors, which together accounted for 80 $MtCO_2$ of industrial emissions in 2011 of which 60 $MtCO_2$ are direct and 20 $MtCO_2$ are indirect.

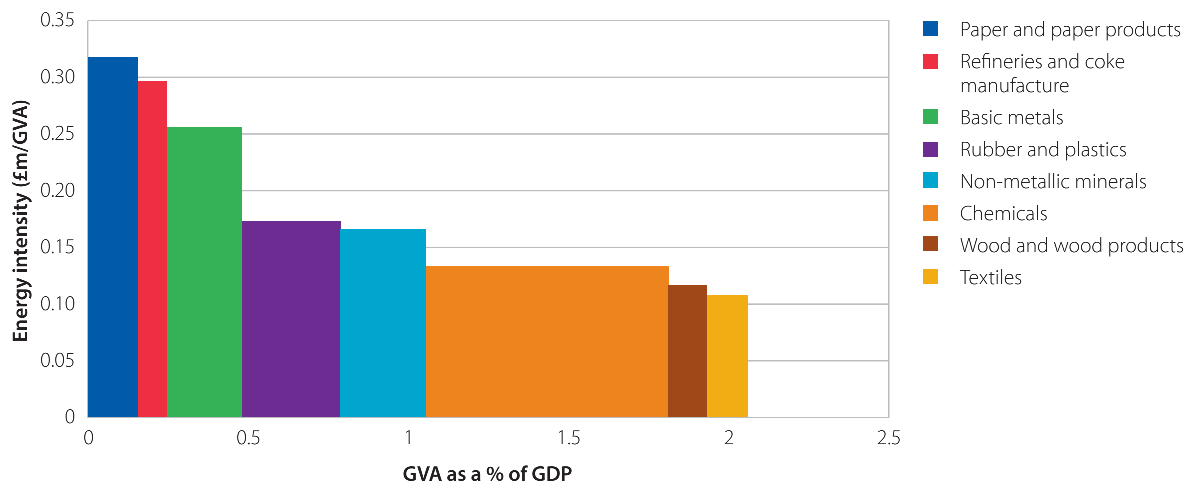
Across industry as a whole, energy costs account for around 3% of total costs. It is therefore unlikely that low-carbon policies will have significant impacts for most of industry. While costs will increase due to higher electricity prices, for most of industry the impact should be small:

1 CCC (2013) *Reducing the UK's carbon footprint* available at www.theccc.gsi.gov.uk.

- In our December 2012 Energy prices and Bills report we estimated that energy costs would rise by 20–25% from 2011 to 2020 for industrial users, due to low-carbon policies;
- Assuming a 3% share in total costs, this will result in total cost increases of around 0.6%;
- If this were passed through to higher prices then it would add 6 pence to every £10 spent on manufactured goods.

There is a higher risk of competitiveness impacts for energy-intensive firms, defined as spending around 10% or more of their Gross Value Added (GVA) on energy. The key energy-intensive industries are paper, basic metals, non-metallic minerals, coke manufacture and refineries, chemicals, rubber and plastics, wood, wood products and textiles (Figure 2.1).

Figure 2.1: Energy intensive industries energy costs and GVA, 2011



Source: CCC calculations based on ONS and DECC data.

Energy costs in the energy-intensive sectors represent 5 to 30% of total costs[2]. Given that energy is a larger proportion of total costs, these industries have a relatively higher incentive to reduce energy consumption and therefore emissions than manufacturing as a whole. Since 1990, industry direct emissions have reduced by 27%. Indirect emissions have also reduced substantially, by 26% between 1990 and 2011; however this is largely due to decarbonisation of the power sector rather than mitigation measures in the industrial sector.

To the extent that these sectors face competition with countries that are less carbon-constrained, low-carbon policies can reduce profits and over time lead to offshoring of production. It is possible that trade intensity[3] increases over time and supply chains globalise, which would result in a greater competitiveness risk associated with any increase in energy costs.

Together the energy-intensive industries account for around 2% of UK GDP (2.5% of GVA[4]) and 2% of total UK employment (around 600,000 jobs). Only a portion of these jobs, around

2 Energy costs are defined here as gas and electricity costs (i.e. excluding petroleum products and solid and manufactured fuels).
3 Defined as (value of imports + exports)/(value of domestic production + imports).
4 Economic activity in each country or region can be measured in terms of Gross Value Added (GVA), which quantifies the contribution to the economy of each individual producer, industry or sector in the United Kingdom. Gross Domestic Product (GDP) is a key indicator of the state of the whole UK economy including taxes and subsidies, such that: GVA + taxes on products – subsidies on products = GDP.

160,000 in some estimates[5], are in the energy-intensive parts of these industries. The chemicals sector is the largest in terms of value-added, contributing over £9bn to UK GVA in 2011, followed by rubber and plastics (£8bn). On the lower end of the range are wood and textiles, both contributing around £2bn.

Energy-intensive industries can be significantly more important in particular regions, reflecting factors such as access to ports, availability of raw materials, development of the supply chain, and skills clusters.

- **Wales:** the energy-intensive industries account for 7% of GVA and 4% of employment:
  - Wales accounts for around a fifth of UK iron and steel output and over a third of output from the UK production of paper and paper products.
  - Access to ports and raw materials and the development of clusters (e.g. around Port Talbot) are key drivers.
- **Scotland:** Energy-intensive industries are also more concentrated in Scotland than in the UK as a whole, accounting for over 3.3% of Scottish GVA, although they account for a lower share of employment (around 1%) than in the UK as a whole:
  - Scotland accounts for a sixth of UK chemical industry output. Around a fifth of the UK's paper production is in Scotland, reflecting the large forest resource. Several of the UK's largest paper manufacturers and downstream processors are based in Scotland.
  - One-sixth of the UK chemicals output is produced in Scotland. The petro-chemical cluster around the Grangemouth refinery (in Falkirk) is a large source of local employment, and the majority of Scotland's production of organic chemicals, pesticides and agro-chemicals occurs there.
- **Northern Ireland (NI):** Energy-intensive industries account for a slightly higher share of GVA (3.1%) than the UK as a whole, and around the same share of employment (1.9%):
  - Chemicals, rubber and plastics and non-metallic minerals are the key sectors, together accounting for more than 70% of NI energy-intensive industry output.

Competitiveness impacts for energy-intensive industries associated with measures to reduce emissions

Measures to reduce direct emissions to 2020

In our 2008 report[6] we assessed the impact of reducing direct emissions to 2020 on energy-intensive industries. That report concluded that the carbon price could impose competitiveness risks to these sectors.

Within the EU ETS, energy-intensive industry faces the cost of purchasing allowances or investing in low-carbon technologies, which potentially place it at a competitiveness risk

5 TUC/EIUG (2012) *Building our low-carbon industries* available at http://www.tuc.org.uk/tucfiles/352/Buildingourlowcarboninds.pdf and Environmental Audit Committee, (2012).
6 CCC (2008) *Building a low-carbon economy* available at http://www.theccc.org.uk

compared to trading partners that do not face a carbon constraint. In order to address this competitiveness risk, the EU has developed an approach to giving free EU ETS allowances to energy-intensive industries regarded as at risk of global competition (Box 2.1).

Box 2.1: Criteria for free allocation of allowances in the EU ETS

During Phase III of the EU ETS (2013–2020), sectors deemed at risk of carbon leakage will be given 100% free allowances. Other sectors receive less; 80%, declining to 30% in 2020. Free allowances are granted up to a specified benchmark, which is the level of emissions consistent with the average greenhouse gas emission performance of the 10% best performing installations in the EU producing that product.

A sector is deemed to be exposed to a significant risk of carbon leakage if:

- The sum of direct and indirect costs imposed by the EU ETS would lead to an increase of production cost of at least 5% of Gross Value Added (GVA); and the trade intensity of the sector with countries outside the EU is above 10%; or
- The sum of direct and indirect additional costs is at least 30% of GVA; or
- The non-EU trade intensity is over 30%.

A study by Martin et al (2012)[7] assessed the effectiveness and efficiency of the EU criteria set out to determine whether sectors are at risk of leakage, and hence eligible for free allowances. They used firm-level data in six EU countries, together with interviews with over 750 managers of manufacturing firms matched to financial data from the OECD ORBIS dataset.

They found that carbon intensity was a good indicator of the risk of carbon leakage, but that trade intensity was not. As currently defined, the EU trade intensity criterion is not precise enough to capture downsizing risk, and import penetration was a better indicator of risk or trade with less developed countries.

The study suggested that two simple modifications of the EU criteria would lead to significant savings in terms of auction revenues:

- If free allowances are targeted at sectors with a carbon intensity of at least 30% or where trade intensity is over 30% and carbon intensity is over 5%, this could result in savings of €6.7bn across the EU ETS.
- If the trade intensity measure was adjusted to represent trade with less developed countries only, this could result in savings of €2.8bn.

The study also suggested gains could be made if allocation were made at the firm level, where the marginal risk of outsourcing could be targeted, due to heterogeneity within sectors. However, the authors recognise the practical difficulty in implementing such a scheme.

Source: EU guidelines http://ec.europa.eu/clima/policies/ets/cap/leakage/index_en.htm and Cambridge Econometrics
Notes: The ORBIS dataset contains firm-level financial information for public and private companies worldwide using data from a number of sources. See http://www.bvdinfo.com/About-BvD/Brochure-Library/Brochures/ORBIS-brochure

We commissioned Cambridge Econometrics[8] (CE) to assess the extent of free allocation to 2020 for at-risk sectors, based on projections of industrial output and consumption consistent with our first three carbon budgets. Surplus allowances can result in over-allocation in Phase I and II of the EU ETS (in part due to recession-related falls in output) and the implementation of low-carbon measures. To the extent that surplus allowances are a result of over-allocation (i.e. rather than genuine emissions reductions through the implementation of low-carbon measures) this could also imply windfall profits in some cases.

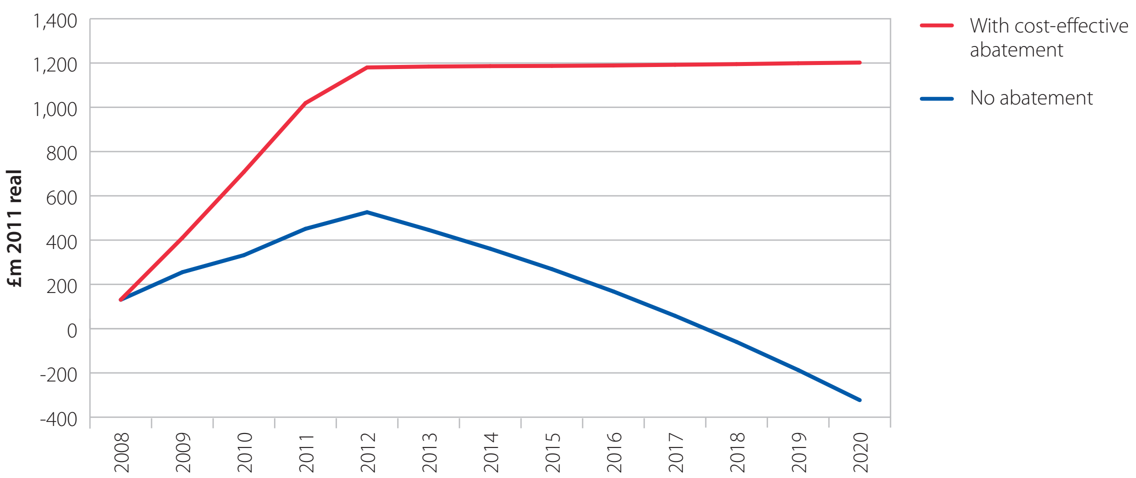
- Energy-intensive industry is over-allocated by around £530m in Phase II. Given banking between phases, surplus allowances are expected to continue in Phase III.

7 Martin et al (2012) *Industry compensation under re-location risk: a firm-level analysis of the EU ETS* available at http://cep.lse.ac.uk/pubs/download/dp1150.pdf
8 Detail of this analysis is contained within the supporting report by ICF and CE (2013), available at www.theccc.org.uk

- Benchmarking[9] of allowances in Phase III erodes the surplus. This results in most energy-intensive industries having a deficit of allowances before 2020.
- However, some specific sectors may remain in surplus. For example, basic metals (including iron and steel) has surplus allowances of £450m in 2020. The implication is that some businesses may be more than fully compensated under the current regime.
- The implementation of abatement measures generates allowances. If a cost-effective level of abatement is implemented, energy-intensive industry as a whole would be expected to generate a surplus of £1.2bn allowances by the end of Phase III (Figure 2.2).
- Even with the implementation of abatement measures, the refineries sector has a shortfall of allowances in 2020, as a greater share of allowances from this sectors is auctioned (i.e. they have a larger proportion of onsite power generation which does not receive free allowances). However, analysis conducted for the fourth carbon budget suggests that there is potential for further low-cost abatement in this sector in the 2020s (e.g. around 4 $MtCO_2$ by 2030), which may help offset these additional costs.

Overall the results confirm an assessment by DECC which indicated that the surplus of allowances would remain significant through much of Phase III, with the implication that competitiveness risks are limited to 2020[10].

Figure 2.2: Estimated cumulative value of EU ETS allowances in UK energy-intensive industry



Source: ICF and Cambridge Econometrics (2013); further CCC calculations.
Notes: Based on a carbon price of £6/tCO_2 in 2008, rising to £8/tCO_2 in 2020.

9 Free allowances are granted up to a level of emissions consistent with the average greenhouse gas emission performance of the 10% best performing installations in the EU making that product.
10 Although not confirmed by the European Commission, this assessment depends upon continued selection of sectors as at risk to 2020.

Measures to reduce direct emissions in the fourth carbon budget

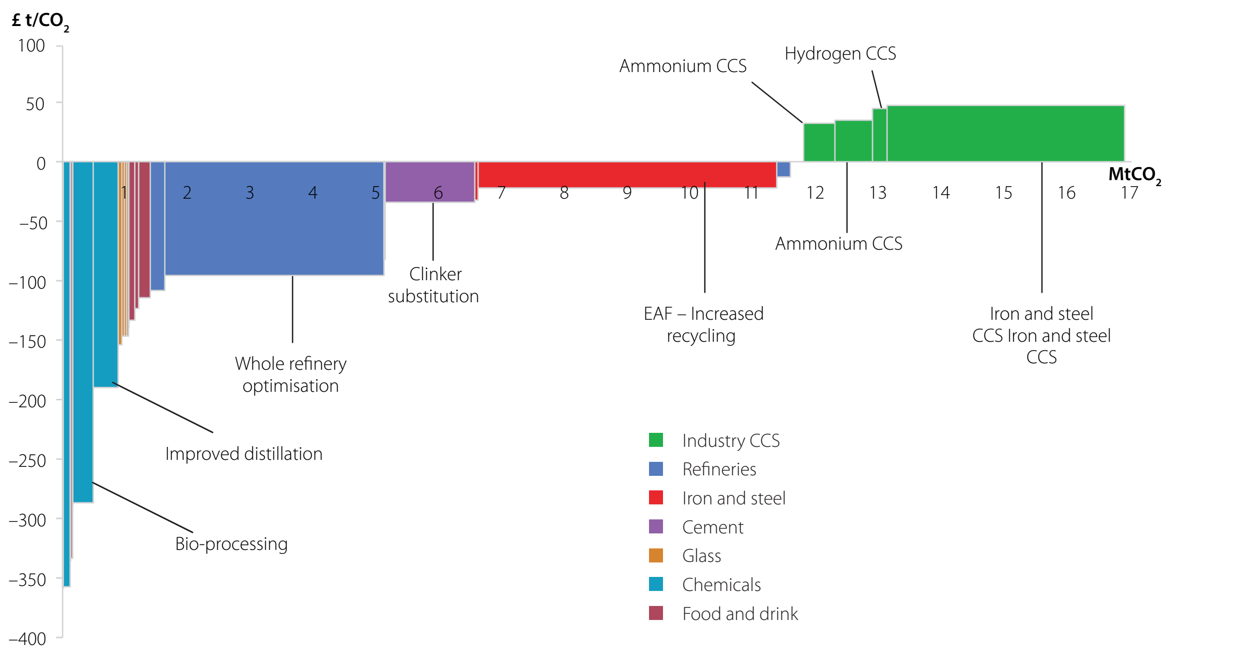
Moving forward to the fourth carbon budget period, our previous analysis assumed a further 26% reduction in emissions from energy-intensive industries in the 2020s through:

- **Energy efficiency.** A combination of short and long payback options, focussing on carbon-intensive sectors (e.g. improvements to blast furnaces and optimisation of refineries) account for a 10% reduction in emissions in the 2020s.
- **Heat.** A further 12% reduction from replacing fossil fuel heating with biomass and biogas, in low- and high-temperature applications.
- **CCS.** Implementation of first CCS projects in the chemicals and iron and steel industry by 2030.

In considering competitiveness risks related to implementation of these measures, it is important to consider their cost. All of the energy-intensive industry measures underpinning the fourth carbon budget are relatively low-cost. Specifically, they are cost-effective, falling well within carbon price projections for 2020 and beyond, both by the UK Government and the European Commission (EC) in its low-carbon roadmap[11] (Figure 2.3).

The broad implication is that competitiveness risks are manageable as long as the world is carbon-constrained:

Figure 2.3: Measures to reduce emissions in energy-intensive industry in the fourth carbon budget



Source: CCC modelling; AEA (2010).
Notes: Chart shows measures that apply to carbon intensive industry. There are further measures for industry in the fourth carbon budget that do not appear in this chart (e.g. renewable heat and short payback efficiency measures). For a full list of technologies see supporting data on the CCC website.

11 Available at http://ec.europa.eu/clima/policies/roadmap/index_en.htm

- As long as energy-intensive industries remain within the EU ETS, and as long as the carbon price in the EU ETS continues to increase[12], there should be no intra-EU competitiveness risks associated with the fourth carbon budget.
- Current trade among the energy-intensive industries is predominantly with countries in the EU. Although there may be risks between the EU and the rest of the world, any mechanisms required to address these risks will depend on the nature of a global agreement, and the carbon constraint that this implies for EU versus non-EU countries through the 2020s.
- Options to address competitiveness risks on the path to a global deal include continuing the current approach of granting free allowances in the EU ETS, and/or sectoral agreements and border carbon adjustments. Sectoral agreements and border adjustments could provide stronger incentives for reducing emissions than allocation of free allowances, but are likely to be both technically and politically difficult to agree and implement (see longer-term policy discussion below).

We will continue to monitor progress towards an EU 2030 package and a global agreement closely, and consider implications for design of carbon budgets and competitiveness risks.

This approach therefore mitigates competitiveness risks associated with direct emissions; we consider below risks related to indirect emissions, including those associated with the EU ETS.

Measures to reduce indirect emissions

Competitiveness risks arise not just through direct costs but also through measures to decarbonise the power sector which add to electricity prices and raise costs to users. In this section we set out the following blocks of analysis:

- We identify industries most open to competitiveness risks associated with rising electricity prices.
- We identify key trading partners of these sectors.
- We develop scenarios for electricity price increases due to low-carbon policies in the UK, EU and internationally.
- We identify uncertainty over estimates of electricity consumption and scope for energy efficiency improvement.
- We consider the evidence on scope for pass-through of rising electricity costs.
- We model the impact of rising electricity prices on profits under various assumptions about electricity costs in other countries, energy efficiency improvement and scope for cost pass-through.
- We assess the potential for further impacts to arise through increases in costs to non-electricity inputs (i.e. increases in material costs that are caused by rises in electricity costs upstream).

12 The carbon prices underpinning this assessment are consistent with those in Scenario 1 below and assume no back-loading of EU ETS allowances.

- We consider levers for addressing impacts, including approaches in place in the UK and other countries.

Identifying at-risk industries

Competitiveness impacts are likely to be greatest for sectors that are both disproportionately exposed to low-carbon costs levied on electricity bills and highly traded, particularly with countries not exposed to costs arising from climate change policies.

Our analysis therefore focuses on the sectors with high electricity bills as a proportion of GVA (i.e. around 10% and above), which are trade intensive and which are relatively large electricity consumers.

Current energy consumption data are available at a relatively aggregated level from DECC statistics (i.e. Standard Industrial Classification 2), and insufficient to conduct a robust assessment of competitiveness impacts:

- Sectors defined as 'at risk' may be too broad (e.g. the paper and paper products sector where part of the sector is not electro-intense).
- Smaller sub-sectors could be at risk but be excluded if they fall within larger SIC 2 categories that do not qualify as at risk, will be excluded (e.g. parts of the ceramics sector, wood and veneer).

Our approach is therefore to screen for sectors at a high level using current aggregated energy consumption data, and to narrow this selection down with detailed information from historical datasets (i.e. SIC 3 and 4 data were collected until 2007 as part of the Quarterly Fuels Inquiry) and industry consultation.

Sectors that are at the margins of electro- and trade intensity criteria pose a challenge for selecting sectors at risk of competitiveness impacts. This is the case for the aggregated cement, lime and plaster sector, which has an electro-intensity of 9%, however it contains sub-sectors which are more at risk (e.g. the subsector of cement has electro-intensity of 42%). We have included cement, lime and plaster as an illustration of a marginal sector that has intense subsectors and for which cumulative impacts (i.e. direct and indirect impacts) are likely to be large. We excluded others sectors that fall just below the margins of these criteria (e.g. wood and wood products, parts of the chemicals sector).

Refineries and aluminium were initially qualified as at-risk, but later excluded reflecting further information that indicated they were not exposed to substantial low-carbon costs.

- **Refineries**. Although this sector is electro-intensive (electricity costs are 19% of GVA), a high proportion of the electricity consumed is generated on-site, and therefore is not highly exposed to low-carbon costs that are levied on grid electricity.

- **Aluminium**. Since the closure of operations at Lynemouth in 2011, the only remaining aluminium smelter in the UK is Lochaber. Lochaber is located adjacent to a hydro-electricity plant, is almost exclusively powered by renewable electricity, and is therefore exempt from low-carbon policy costs. Although some electricity is imported from the grid, it is not substantial.

The sectors we include in our competitiveness assessment are outlined in Table 2.1.

Table 2.1 Aggregated and detailed sector selection

Parent sector (SIC 2)	Final sector selection using detailed historical data (SIC 3 and 4)	Electro-intensity % (£ electricity bill/ GVA)	Trade-intensity % (imports+exports)/ (output+imports)
Paper and paper products (SIC 17)	Paper, pulp and paperboard (SIC 17.1)	38%	75%
Non-metallic minerals (SIC 23)	Cement (SIC 23.51)	42%	24%
	Glass (SIC 23.1)	11%	46%
	Lime and Plaster (SIC 23.52)	17%	47%
Chemicals (SIC 20)	Manufacture of other basic inorganic chemicals (chlor alkali) (SIC 20.13)	30%	77%
	Nitrogenous fertilisers (SIC 20.15)	41%	
Basic metals (SIC 24)	Iron and steel (SIC 24.1-3)	14%	74%
Rubber and plastics (SIC 22)	Rubber and plastics (SIC 22)	10%	52%

Source: CCC calculations, ONS and DECC data.
Notes: We also consider oxygen which is a key input to the iron and steel sector. More information on this sector is included in ICF and CE (2012).

Identifying key trading partners

Given identification of the key sectors at risk, the next step in our analysis was to identify key trading partners and competitors for these sectors. This was based on an assessment of:

- The UK's current trading partners. We identified the top five importers and exporters for each sector.
- Countries that were major producers of products of the sector, regardless of whether they are currently trading with the UK or not. We identified the top three global producers for each sector, which is an indication of potential future production capacity and possible future trading partners.
- Imminent changes to trade or information about production capacity in other countries that could pose a competitor risk to UK sectors in the future.

This analysis resulted in a long list of trading partners as shown in Table 2.2 below.

Table 2.2: Key trading partners of sectors at risk of competitiveness impacts

Countries	Iron and Steel	Paper	Nitrogenous Fertiliser	Chemicals	Plastics	Rubber	Cement	Glass
Germany	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
France	Δ	Δ		Δ	Δ	Δ	Δ	Δ O
Netherlands	Δ		Δ	Δ	Δ	Δ		
Spain	Δ						Δ	
Irish Republic				Δ		Δ	Δ	
Belgium				Δ	Δ		Δ	Δ
Turkey							×	
Italy								Δ
Russia	Δ×		Δ O				Δ	
Sweden		Δ						
Finland		Δ						
Lithuania			Δ					
Egypt			Δ					
Ukraine			×					
US	O	Δ O		O	O	Δ O	O	Δ O
China	O	O	O	O	Δ O	Δ O	O	Δ
Japan	O	O						O
India			O				O	

Notes: Δ Major trading partner, O Global producer × Possible future competitor. The other global producer for Rubber and Plastics is the EU.
Source: CCC and ICF calculations based on HMRC data. Some data sourced from sector associations.

From this list we developed a short list of competitor countries to take forward for detailed analysis and modelling which we commissioned from ICF and Cambridge Econometrics (ICF and CE)[13]. The short list was chosen to ensure a good representation of trading partners across the different sectors covering both ETS and non-ETS countries. Our final selection included at least three major trading partners and at least two global producers of each sector. The countries considered were Belgium, China, France, Germany, the Netherlands, Turkey, Russia and the US.

These countries capture 50-70% of all trade across these sectors and over half the global market and therefore form a representative sample of current and potential future trade.

13 ICF and Cambridge (2013) *'Assessment of Competitiveness Impacts of Carbon Budgets on Electro-intensive sectors to 2030'* available at www.theccc.org.uk

Electricity prices

Electricity prices in the UK and competitor countries were based on an assessment of existing and future energy and climate change policies that are likely to affect prices to 2030. For the UK, these were based on the analysis set out in our December 2012 Energy Prices and Bills report[14]. For competitor countries, the ICF and CE study reviewed the impact of current and future planned low-carbon policy on electricity prices. The key policies covered were:

- Greenhouse gas trading policies. This covers the EU ETS, the US state emissions trading schemes, the pilot Chinese Emissions Trading Schemes and emerging US regulations.
- Energy efficiency policies and targets
- Renewable energy policies. All countries apart from Russia have renewable energy policies in place or planned shortly. Where the impacts of these are reduced for the electro-intensive sectors (e.g. in Germany and the Netherlands) this is taken into account.
- Energy taxes
- Wider energy policies for example the Amendment of the Atomic Power Action (nuclear phase out) in Germany and the Law on New Organisation of Electricity Markets (ending regulated tariffs) in France.

A more detailed description of these policies and their impact on electricity prices in these countries and sectors can be found in Appendix 2 of the ICF and CE study.

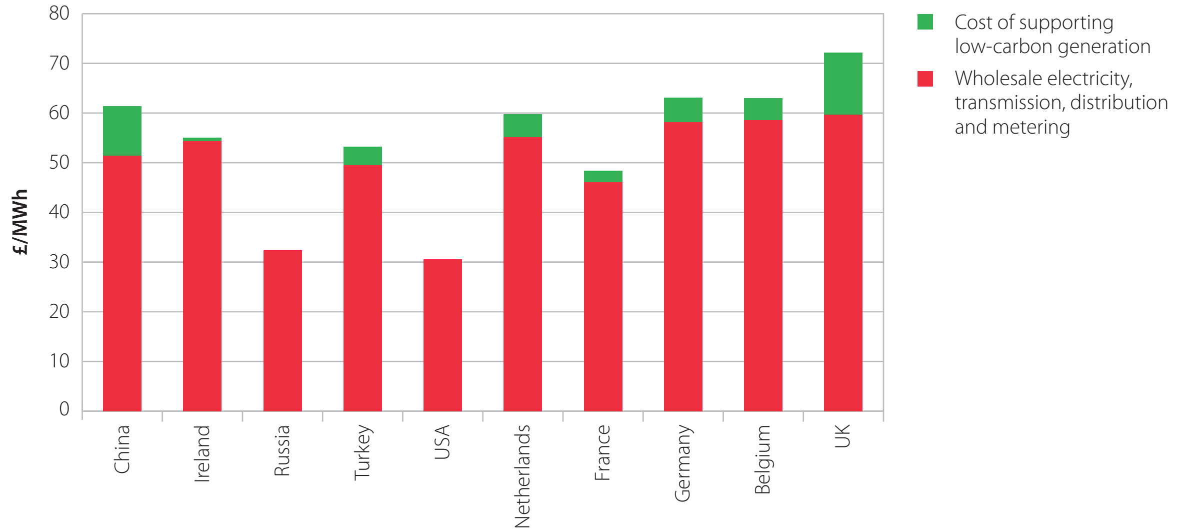
Current Electricity Prices

The analysis shows that current electricity prices for industrial users in the UK are high relative to those in the rest of the EU and internationally, largely reflecting higher base prices (wholesale plus network costs), with greater low-carbon cost adding £12/MWh (Figure 2.4):

- Different base prices reflect several factors, including different supply mixes, fuel prices, network costs, non-energy taxes and market structures. Base industrial electricity prices are high in the UK compared with the other countries in this study and against the EU-15 more generally. This means that, irrespective of the impact of low-carbon policy, UK industrial users are at a competitive disadvantage compared with many other countries. Whilst this can partly be accounted for by the country-specific factors, this should be investigated further, particularly given the UK's relatively competitive wholesale gas prices.
- Greater low-carbon costs reflect a relatively high cost of meeting the 20% EU renewable target in the UK (due to the UK's stretching target and its high share of relatively expensive off-shore wind generation) and the carbon price floor.

14 CCC (2012) op.cit.

Figure 2.4: Electricity prices in the UK and internationally (2011)



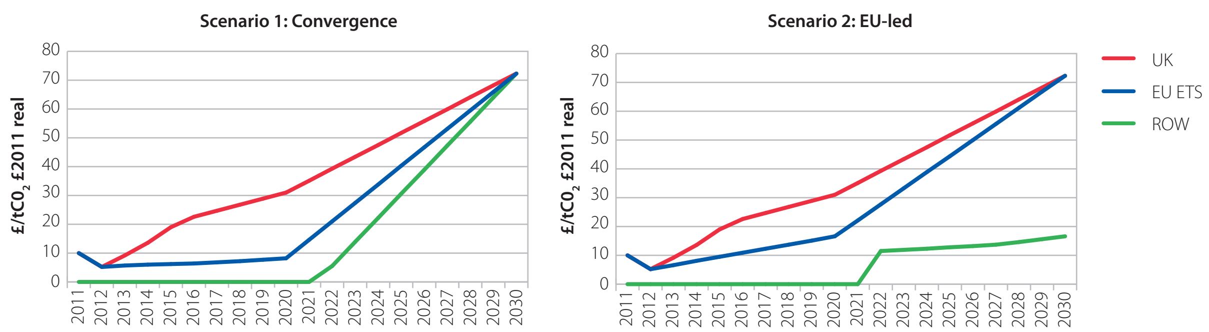
Source: CCC (UK prices), ICF (international prices).
Notes: German costs of supporting low-carbon generation includes exemptions for energy-intensive industries.

In the UK, electricity prices faced by industry vary across sectors depending on the share of electricity consumption that is drawn from the grid compared with on-site generation (i.e. auto generation[15]). This reflects that auto-generation does not currently face costs associated with some low-carbon costs (e.g. the Renewables Obligation. The main sectors that have some auto generation are steel, paper and pulp and chemicals.

Future electricity prices

The previous section identified current low-carbon policies and commitments by competitor countries. In order to project future prices we also need to develop scenarios for future carbon prices. Given uncertainty both in future carbon price trajectories and the coverage of future carbon markets, we consider alternative scenarios to test a range of impacts (Figure 2.5).

Figure 2.5: Carbon price scenarios



Source: CCC calculations, DECC projections available at https://www.gov.uk/carbon-valuation

15 Detail on the policy costs faced by autogeneration compared with grid electricity is covered in detail in CCC (2012) *Energy prices and bills – impacts of meeting carbon budgets* available at www.theccc.org.uk

- **Scenario 1: 'Convergence'**. There is a global carbon price by 2030. The EU ETS carbon price is based on DECC central estimates[16], reflecting futures contracts to 2020, with a move to prices needed to achieve climate stabilisation goals by 2030. The UK faces a carbon price floor (CPF) which is higher than this up to 2030, but converges with EU ETS prices in 2030. The rest of the world (ROW) is assumed to introduce carbon markets from the early 2020s, with prices increasing rapidly to converge with other countries at around £70/tCO_2 by 2030.
- **Scenario 2: 'EU-led'**. This is a stretching scenario for UK competitiveness impacts as UK and EU carbon prices converge as in Scenario 1, but the ROW is on a slower track with no convergence in the forecast period. The EU ETS price is consistent with DECC's higher values used for modelling, reflecting higher demand conditions for allowances, consistent with tighter caps, faster growth and low prices of coal relative to gas. A global carbon price is assumed in the ROW from the early 2020s, and prices are assumed to lag the EU ETS prices by 10 years. This scenario can be consistent with longer term climate stabilisation goals, but tests more challenging EU-ROW competitiveness conditions.

These scenarios are inherently uncertain, particularly in the longer-term. They should not be seen as predictions of actual prices, but are designed to test a range of competitiveness impacts in a carbon-constrained world.

It is important to note that our focus in this report is on scenarios where the world is carbon-constrained, with variation according to how quickly this constraint binds different countries. If other countries were to significantly diverge from this course, this would raise more fundamental questions about the appropriate pace of emissions reduction, rather than competitiveness impacts *per se*. We will consider a wider range of global emissions pathways and carbon price scenarios in our review of the fourth carbon budget, drawing out implications for appropriate ambition in the fourth budget.

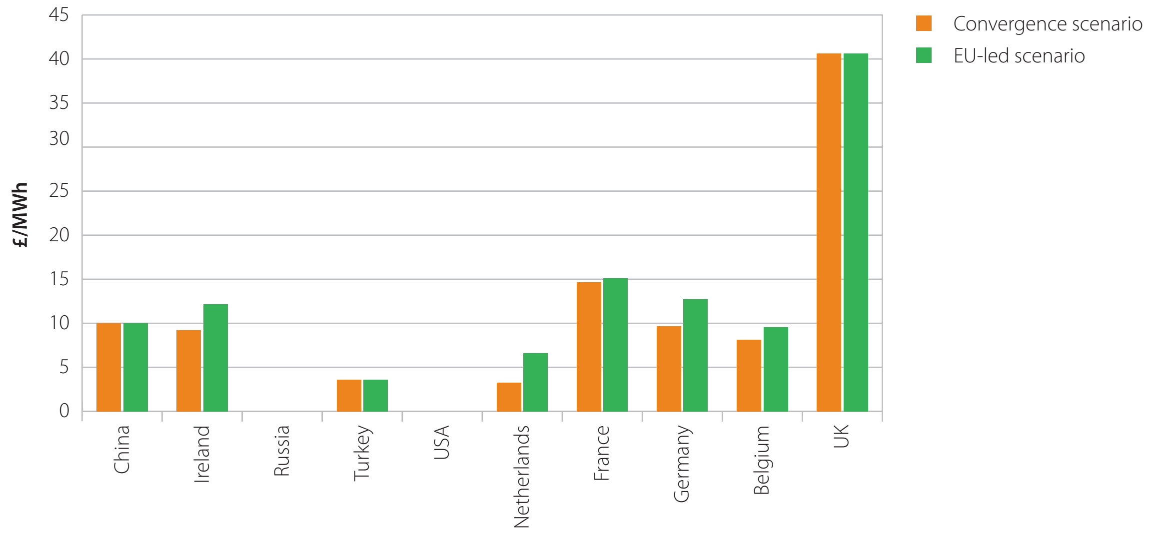
We used our carbon price scenarios, together with our assessment of other elements of costs, to project electricity prices to 2030. We distinguish between impacts to 2020, which reflect current policy, and 2030, which are more uncertain given that they relate in large part to policies not currently in place and to assumed trajectories of the carbon price.

Our projections show significantly higher prices in the UK than other countries in 2020, with convergence through the 2020s, the extent of which depends on the carbon price scenario (Figure 2.6, Figure 2.7).

- **UK electricity prices**. UK electricity price projections are the same under both carbon price scenarios. We project an increase in the component of the electricity price due to low-carbon policies from 1.2 p/kWh in 2011 to 4.1 p/kWh in 2020 and 5.0 p/kWh in 2030. These estimates take account of the impacts of the carbon price floor, support for investment in renewable power generation under the Renewables Obligation, the Climate Change Levy (CCL) and costs associated with Contracts for Difference (CfD). Impacts are lower for industries with autogeneration (e.g. CHP in the chemicals sector).

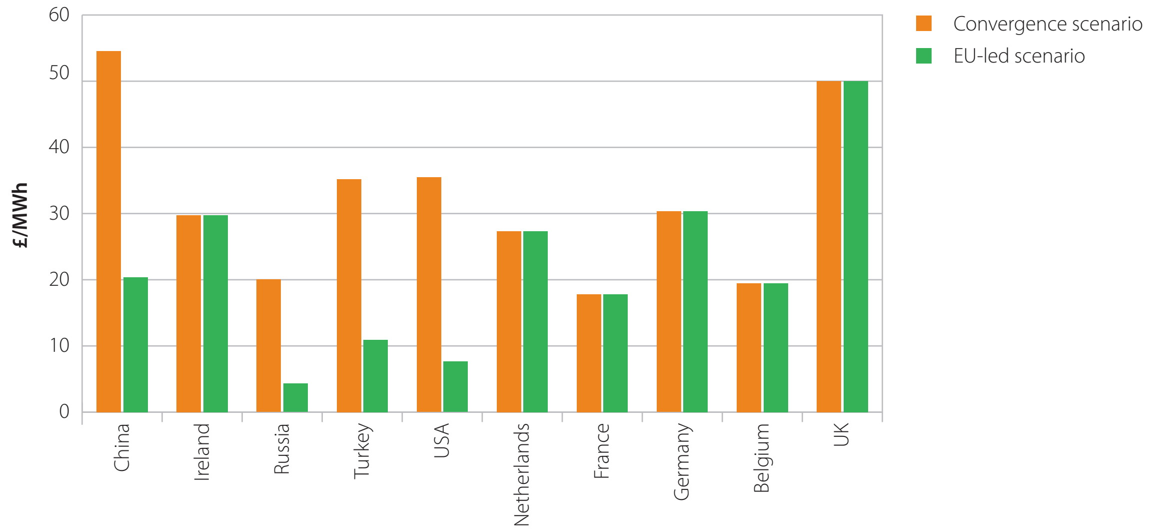
16 Available at https://www.gov.uk/carbon-valuation

Figure 2.6: Impact of low carbon policies on electricity prices (2020)



Source: CCC (UK prices), ICF (international prices).
Notes: Projected UK costs for low-carbon policies are set out in detail in CCC's 2012 report *Energy prices and bills – impacts of meeting carbon budgets*.

Figure 2.7: Impact of low carbon policies on electricity prices (2030)



Source: CCC (UK prices), ICF (international prices).
Notes: Projected UK costs for low-carbon policies are set out in detail in CCC's 2012 report *Energy prices and bills – impacts of meeting carbon budgets*.

- **EU and international electricity prices**. We consider low-carbon policies in the UK's key trading partners, and project these forward under the carbon price scenarios above. In the 'Convergence' scenario, we find that the low-carbon component of electricity prices increases from 0-1.0 p/kWh currently to 0-1.5 p/kWh in 2020 and 1.8-5.5 p/kWh in 2030. The largest differential compared with the UK is in 2020; by 2030, the gap narrows leading to a more even spread of low-carbon costs, with some countries having higher overall electricity prices than the UK. Under the 'EU-led' scenario significant electricity price differentials remain with non-EU countries, so that by 2030, UK low-carbon costs are 3.0-4.5 p/kWh higher than countries outside the EU ETS.

Current and future electricity consumption

In previous analyses of carbon budgets, we set out estimates of energy efficiency potential. We now update those estimates.

Electricity consumption of electro-intensive industries is uncertain due to different estimates of current consumption across data sources and uncertainty over scope for energy efficiency improvement. Both DECC and the ONS publish data that can be used to derive sector-level electricity consumption. Data collection is through surveys which provide an incomplete inventory of the electricity consumption in a sector, and rely upon accurate reporting. Variation between these datasets is substantial in the case of some sectors. For example, in rubber and plastics, consumption derived from DECC sources is around 11 TWh in 2011, compared with around 6 TWh from ONS data.

Where there is scope for energy efficiency improvement, this offers potential to reduce the burden of carbon policies, which impose a cost for each unit of electricity consumed. Improvement will also provide a buffer against electricity price increases more generally, given that associated cost reductions go beyond avoiding low-carbon policy costs. Our analysis suggests that there may be scope, depending on the industry, for around a 5–10% reduction in electricity consumption from energy efficiency improvement in electro-intensive industries in the UK (Table 2.3), and a 0–20% reduction elsewhere:

- Electricity energy efficiency opportunities in the industrial sector include efficient motors and pumps, compressed air systems and lighting.
- We have updated previous estimates using evidence submitted to us by industry sectors on electro-efficiency potential by 2020. Due to long lead times in the turnover of capital stock, further efficiency potential may be possible beyond 2020 as equipment reaches the end of its lifetime (e.g. efficient electric arc furnaces).

Table 2.3: UK electricity energy efficiency improvement estimates 2011 to 2020

	UK (industry sector estimate unless specified)
Paper and paper products (SIC 17)	7%
Cement (SIC 23.51)	4%
Glass (SIC 23.1)	5%
Basic inorganic chemicals (SIC 20.13)	11%
Nitrogenous fertiliser (SIC 20.15)	11%
Iron and steel (SIC 24.1-3)	8% (CCC estimate)
Rubber and plastics (SIC 22)	4% (CCC estimate)

Source: Electrical energy efficiency estimates for UK submitted by industry sector representatives unless otherwise stated.
Notes: Recent CCA published energy efficiency targets suggest that potential could be much higher for rubber and plastics (e.g. 17% for rubber and 10% for plastics). Further evidence is required for this sector. The energy efficiency estimate for some sectors is mostly electricity efficiency potential but reflects some level of direct fuel efficiency from non-traded parts of the sector. As a result may be a slight overestimate. CCC estimates are in line with fourth carbon budget advice.

The ICF and CE study estimated current electricity intensity and future improvements in key competitor countries. These were difficult to estimate accurately due to:

- Data gaps around current capital stock, and uncertainty around assumptions regarding future consumption and technological improvements in competitor countries.
- For some sectors (e.g. cement sector and parts of the chemicals sector) reliable estimates of current electro-intensity are reported by sector associations. Where this was not available, estimates were based on countries where the sector was thought to be sufficiently similar to provide a reasonable proxy, but is not exact (e.g. chlorine industry in Belgium similar to Netherlands).
- Projected efficiency improvements are based on International Energy Outlook estimates[17], which project international energy consumption and output for industrial sectors based on projected technology and demographic trends.

Our modelling of cost and profit impacts for electro-intensive industries includes various scenarios for electricity consumption to allow for these uncertainties.

Scope for cost pass-through

The characteristics of the market in which firms operate shape their ability to pass through higher costs. At the extreme, in an internationally competitive market where foreign and domestically produced goods are perfect substitutes, there is limited scope for industry to pass through differential electricity price increases, since this would erode market share. In this case, electricity price increases would have to be absorbed and would be a direct hit on profits.[18]

However, in many cases there are barriers to trade – for example, due to high transport costs or regulations associated with the transport of hazardous materials (e.g. some chemicals) or there may be benefits of being located close to market, where just in time deliveries are important. In such cases there may then be scope to pass through higher electricity costs, and less concern about competitiveness risks. To the extent that firms can pass on some costs, they will benefit from higher prices, which will partly offset the impact of higher costs. The overall impact on firms' profits will be lower than under the case of no pass-through.

Although the degree to which firms can pass through is not directly observable and therefore difficult to measure, there is evidence available which can inform this issue. The ICF and CE research assessed this, and they suggested a range for cost pass-through specific to each sector. These vary from a low range of 10-40% to a high range of 20-75% for the different sectors (Table 2.4).

17 IEO (2011) by US energy information administration available at www.eia.gov-forecasts-ieo
18 Businesses may also decide to restructure wages or reduce shareholder returns.

Table 2.4: Sectoral pass-through rates

Sector	Pass-through rate	Key sector characteristics
Paper, pulp and paperboard (SIC 17.1)	20-40%	• Paper products are on the whole fairly standardised and homogenous, making the industry very competitive. • Demand from this sector has been on a downward trend in the past decade due to imports, with output halving since 1990. • Most modern paper mills have their own CHP unit.
Cement (SIC 23.51)	30-75%	• Concentrated market with high transport costs, high and steady barriers to entry and few substitutes. • Market characterised as a series of regional oligopolies, though imports increasingly set the price at ports due to the relative cost effectiveness of sea freight. • The three main products are clinker, Portland cement and other hydraulic cements. Demand for these comes mainly from the construction sector, which is highly pro-cyclical.
Glass (SIC 23.1)	10-45%	• Wide variety of products with varying degrees of non-price competition, import penetration and potential for substitutes. • The two main products are flat glass and hollow glass: – Flat glass is produced mainly for the construction, automotive and furnishing markets, and is both highly concentrated and traded internationally. – Demand for European container glass largely from the food and drink industry.
Manufacture of other basic inorganic chemicals (chlor alkali proxy) (SIC 20.13)	30-75%	• Highly concentrated market – two main companies in UK manufacturing chlorine and caustic soda. • Imports remain low due to the hazardous nature of the products, with high transport and storage costs. EU standards and restrictions act as non-price barrier to entry. • Most chlorine produced in the EU is used in production nearby, although products using chlorine such as PVC are much more highly traded.
Nitrogenous fertilisers (SIC 20.15)	10-20%	• UK industry is focused on the production of mineral or chemical fertilisers and of ammonium nitrate. • There is high import competition, in part due to the fairly homogeneous product markets. • Mineral fertilisers highly traded globally as only mined in a few locations.

Table 2.4: Sectoral pass-through rates

Iron and steel (SIC 24.1-3)	25-75%	• There are two routes for producing steel: through a basic oxygen furnace or an electric arc furnace. • There is medium degree of concentration, with high and steady barriers to entry and globalising supply chains. • Output is pro-cyclical but in long-term decline in Europe. • There is a range of products with varying degrees of specialisation and non-price competition.
Rubber and plastics (SIC 22)	40-75%	• Plastics: supplies diverse range of sectors, with packaging the largest source of demand. • Highly fragmented market with a number of small to medium-sized enterprises competing for downstream consumer demand. • Trade is high and increasing though transport costs may be limiting factor, particularly of low-grade items. • Rubber is a smaller part of the sector, with products largely serving the automobile industry. Trade is high and increasing.

Source: ICF and CE (2013) op.cit and supporting evidence from IBIS World available at www.ibisworld.co.uk
Notes: The estimates were subject to a peer-review, which suggested that while the ranges encompass the spectrum of possibilities, for some sectors pass-through is likely to be towards the higher end of the range (e.g. cement, due to high transport costs). The peer review by Karsten Neuhoff (2013) is available at http://www.theccc.org.uk/publication/carbon-footprint-and-competitiveness/
For further detail of the characteristics of the sectors see Appendix 6 of ICF and CE (2013).

Given the uncertainty regarding pass-through rates and potential for these to change overtime, in our scenarios for the impact of electricity price increases on profits we show the extreme of zero pass-through as well as the range suggested by ICF and CE.

This approach leads to a range for the possible impacts of electricity price rises on businesses.

Further empirical work on pass-through rates, in particular focussing on the impact of unilateral increases in the UK electricity price, would be useful in providing a more robust evidence base.

Profit impact of electricity price increases

In order to assess potential competitiveness impacts we commissioned ICF and CE to develop a model[19] relating low-carbon costs to sector profits and employment in electro-intensive industries in the UK (Box 2.2).

19 ICF and CE (2013) op. Cit.

Box 2.2 : Modelling approach

We commissioned ICF and Cambridge Econometrics to develop a model to quantify the impact of future changes in electricity prices faced by sectors.

The model assumes that faced with an increase in electricity bills, the sector can either absorb or pass-on the cost. To the extent that costs are absorbed, sector profits and GVA are reduced, but consumers do not face higher prices so demand and output remain unchanged. If costs are passed through, consumers face higher product prices, and demand for UK products falls, which is substituted by increasing imports. This reduces UK sector output, profits and GVA.

Similar relationships exist in increases electricity prices from low-carbon policies affecting these sectors in key trading partners. Therefore relative electricity prices (UK versus trade partners) determine the competitiveness impacts on a sector, rather than UK electricity price increase alone.

The model only reflects 'first-round' impacts on the sector in terms of profits, GVA, output and employment. It may however be that a business will reduce wages or make redundancies in response to higher electricity costs. However, if costs are wholly absorbed within a sector, the impact on GVA and profits (as reported in the model) is the worst case scenario for the sector, since it would be implausible for a sector to take any action which would result in an impact that was worse than absorbing 100% of the additional cost. Therefore, although the above second round dynamic effects are outside the scope of the model, the results do give an indication of the worst case scenario on profits.

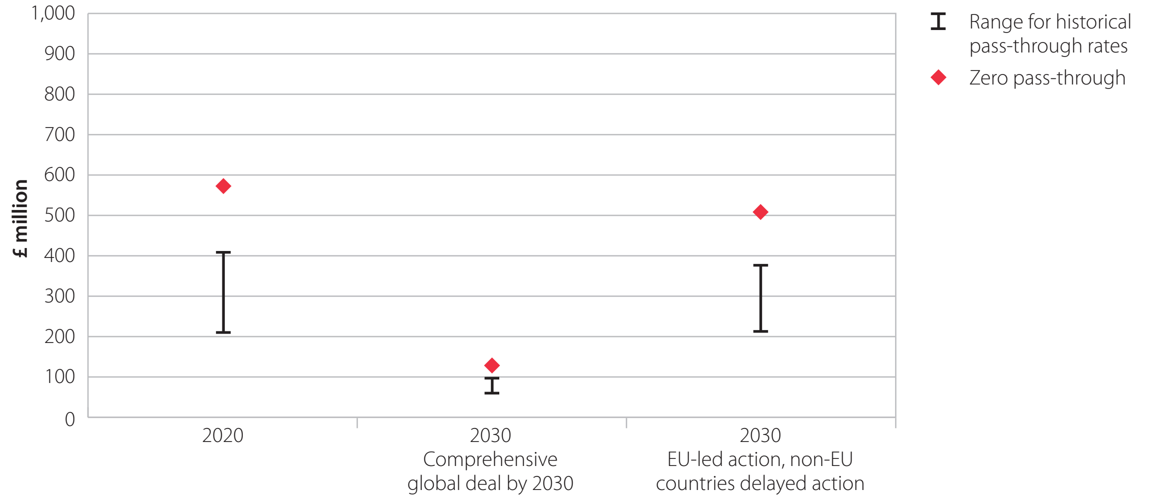
A key sensitivity in the model is pass-through rates, for which we develop a range to demonstrate the spectrum of results. The model is also very sensitive to energy consumption, and energy efficiency assumptions. A limitation of the model is that it assumes constant trade shares (i.e. the level of imports from each region) in future. The alternative would be to model the impact of changing electricity prices on location of production. However, UK trade data suggests that import shares of the products modelled are fairly stable over time, which indicates that there are not large swings toward the marginally cheaper producer, and that import penetration is determined by other factors in addition to prices.

Source: CE and ICF (2013) available at www.theccc.org.uk

We estimate that higher electricity prices due to currently legislated carbon budgets could reduce profits of electro-intensive firms range by £150-£400 million in 2020, reflecting the range of evidence on scope for cost pass-through, and for estimates of consumption in different datasets. In the extreme case of zero cost pass-through, the fall in profits could rise to £600 million in 2020. Projected impacts in 2030 are lower (e.g. £50-150 million assuming a global carbon price by 2030 and up to £500 million if there is delayed action outside the EU) (Figure 2.8).

- **Profit impacts due to higher electricity prices associated with carbon budgets in 2020**
  - The total profit of electro-intensive industries considered in our analysis was around £6 billion in 2011.
  - The profit impact under assumptions of low current consumption and high cost pass-through is £150 million in 2020.
  - This increases to £200 million if DECC data on current consumption are used rather than ONS estimates.
  - At the low end of the range for cost pass-through, projected profit impacts are around £400 million in 2020.

Figure 2.8: Profit reductions due to low-carbon policy



Source: CCC calculations, ICF and Cambridge Econometrics.
Note: Chart uses consumption estimates derived from DECC data. ONS data brings lower end of range to around £150 million in 2020.

- In the extreme case of zero scope for cost pass-through, projected profit impacts are £600 million.
- The projected impact of rising electricity prices on costs is around £700 million in 2020 (with lower impacts on profits due to projected increases in electricity prices in other countries, and cost pass-through).
- These figures assume energy efficiency improvement in the UK and elsewhere in the world. If the UK were to outperform other countries on energy efficiency improvement, lower profit impacts would ensue. Conversely, if other countries were to deliver the potential that we have identified and the UK were to fail to deliver, profit impacts would be higher.

- **Profit impacts in 2030:**
  - Assuming a global carbon price as in the 'Convergence' scenario profit impacts fall to £50–£150 million reflecting the range of evidence on scope of cost pass-through.
  - Under the 'EU-led' scenario where carbon prices in the rest of the world lag those of the UK and EU, profits are reduced by £200–£500 million.

Sector-by-sector results for 2020 are given in Table 2.4.

Table 2.5: Profit impacts on electro-intensive industries in 2020

Sector (£m 2011 real)	Zero cost pass-through	High cost pass-through
Paper, pulp and paperboard (SIC 17.1)	85	25
Cement, including lime and plaster (SIC 23.51 – 23.52)	50	15
Glass (SIC 23.1)	35	25
Manufacture of other basic inorganic chemicals (chlor alkali proxy) (SIC 20.13)	60	25
Nitrogenous fertilisers (SIC 20.15)	25	20
Iron and steel (SIC 24.1-3)	65	20
Rubber and plastics (SIC 22)	260	80
Total	580	210

Source: CCC calculations. ICF and CE (2013).
Notes: Estimates rounded to nearest £5m.

This analysis can inform design of polices aimed at offsetting electricity price impacts and limiting competitiveness impacts for electro-intensive industries.

There are also further indirect impacts on industry due to higher electricity prices driving up costs of materials used in production processes. We now show analysis that suggests these impacts are relatively limited.

Impacts from increases in non-energy input costs

There are further indirect impacts on industry due to higher electricity prices driving up costs of materials used in production processes (e.g. oxygen as a key input to steel production). Our analysis suggests these impacts are limited, with further profit margin reductions of 0-0.3 percentage points in 2030 under the EU-led scenario.

The implication is that impacts on profits due to electricity costs embedded in material inputs to industry are limited, and our approach is not to include them in total profit impacts.

There may be isolated examples where this should be considered further (e.g. fertilisers). Full results from this analysis are available in ICF and CE (2013).

Policy levers for addressing profit impacts

Short-term policy options to reduce competitiveness risks

Other countries have acted to address competitiveness risks due to rising electricity prices:

- The German Government offers exemptions from costs of renewables and other taxes for energy-intensive users that amount to around £6.8 bn average annually.[20]

20 TUC (2012) submission to the Environmental Audit Committee inquiry into the energy-intensive industries' compensation scheme available at http://www.tuc.org.uk

- Other European governments have offered similar exemptions (e.g. Netherlands). This is consistent with State Aid rules, as noted by the European Commission in its recent Green Paper[21]: "State Aid rules related to the ETS allow Member States, as from 2013 to provide compensation for parts of the indirect ETS costs for the most electricity intensive sectors. Furthermore, environmental state aid rules currently allow targeted exemptions for industry from energy related taxes".
- The Australian Government has offered around £2 bn average annual assistance to emissions intensive and trade exposed industries. This is designed to cover both direct and indirect impacts (i.e. is comparable to the value of UK support mechanisms for electricity price rises and free allocation of allowances in the EU ETS).

The UK Government has recognised competitiveness risks associated with rising electricity prices and put in place arrangements to limit competitiveness risks:

- In the 2011 Autumn Statement the Government committed £250 million for the period 2013-2015 to offset the impact of rising electricity prices for electro-intensive industries.
  - Up to £100m is compensation for impacts from the Carbon Price Floor pass-through. The Government is currently consulting on the eligibility criteria, with a view to making this available from 2013, subject to state aid approval.
  - Up to £110m is compensation for indirect impacts of the EU ETS on electricity prices, in line with European Commission state aid guidelines. EU rules for eligibility were set in 2012 and compensation will be available from 2013.
  - £40m uplift on relief from the Climate Change Levy (from 65% to 90%) is to be introduced from April 2013.[22]
- In November 2012, exemptions were announced to offset the additional costs arising under Electricity Market Reform as part of the 2012-13 Energy Bill. Although the value of these exemptions has not currently been specified by Government, we estimate they would amount to around £350m in 2020 if extended to the at-risk electro-intensive industries identified above.
- In the 2013 Budget, further exemptions were announced to the metallurgical and mineralogical process sectors regarding the CCL, to be introduced in 2014.

The total value of all these measures is at the high end of the range of modelled profit impacts for electro-intensive sectors in 2020 (up to around £475m annually, before the addition of the CCL exemptions, compared to profit impacts of £150-600m).

In designing a support package for the period after 2015, the Government will have to develop the evidence base on future increases in UK electricity prices relative to other countries, scope for energy efficiency improvement, scope for cost pass-through, and materiality of electricity price impacts for firm location and investment decisions.

21 European Commission (2013) 2030 framework for climate and energy policies, Green Paper.
22 Energy-intensive industries compensation scheme available at http://www.publications.parliament.uk/pa/cm201213/cmselect/cmenvaud/669/669.pdf

For the purposes of the fourth carbon budget review there are two key implications:

- The largest impacts occur due to electricity price increases to 2020 from policies to which the Government is already fully committed; incremental impacts due to electricity price increases in the 2020s are relatively small.
- Rising electricity prices to 2030 are likely to have relatively small profit impacts, for example compared to revenue expected from carbon policies (e.g. £3bn in 2020 from the carbon price underpin), and affordability impacts that would ensue from allocating costs associated with low-carbon policies away from electro-intensive industries to other electricity consumers (e.g. adding around £5 to the typical household bill in 2020).

Competitiveness risks associated with rising electricity prices are therefore manageable, and should not be regarded as prohibitive in the context of ambition currently legislated for the fourth carbon budget.

Longer-term policy options to reduce competitiveness risks

The previous section considered the degree to which the electro-intensive industries would require support to compensate for the competitiveness effects of future electricity price rises resulting from measures in the fourth carbon budget. Over the longer-term, the priority policy option to minimise competitiveness risks is to achieve a comprehensive global deal. A global carbon price covering all sectors would create a level playing field for industries.

Where a global deal does not lead to equal carbon prices across regions or sectors then additional policies could be required in order to ensure a transition to a level playing field. Two main policies which have been discussed internationally and which could be used to support a global deal are sectoral agreements and border carbon adjustments.

Sectoral agreements

Sectoral agreements can refer to a wide range of possible measures, including:

- Multilateral agreements between governments to regulate emissions from a sector
- Unified product/efficiency standards for sectors or technologies across countries
- Cooperation on research or deployment of technologies
- Industry initiatives to reduce emissions

There are numerous examples of successful sectoral agreements in practice (Box 2.3).

Sectoral agreements could be linked over time to support a global deal. For example, a system of sector cap and trade schemes could become part of regional carbon markets under a global deal.

Box 2.3 : Sectoral agreements in practice

A range of sectoral agreements and policies can be found, reflecting a mix of regulatory and voluntary approaches at international, regional and national levels:

- **International aviation and shipping**. The Kyoto Protocol delegated regulation of international aviation and shipping emissions to the International Civil Aviation Organisation (ICAO), and the International Maritime Organisation (IMO). The IMO has recently agreed a global energy efficiency standard for new ships (the Energy Efficiency Design Index). The ICAO have agreed an aspirational fuel efficiency improvement of 2% per year, with carbon neutral growth from 2020.
- **EU ETS sector benchmarks**. In the EU ETS, industrial operators are granted free allowances up to a level of emissions consistent with the average greenhouse gas emission performance of the 10% best performing installations in the EU making that product. This therefore gives incentives to adopt more efficient technologies.
- **Cars**. The EU has agreed emission standards for new cars, and these apply to all Member States. Other countries have adopted stretching new car fuel efficiency targets with similar implied reductions to the EU (e.g. CAFE standards in the US).
- **Industry energy efficiency.** In the UK, many industries have Climate Change Agreements. These include negotiated targets between industry sectors and government, with a 90% discount on the Climate Change Levy for participating sectors. The latest targets were set out to 2023.
- **Montreal Protocol.** A global international agreement to regulate (and eventually phase out) production of ozone depleting substances by the chemicals sector.

In principle sectoral agreements address competitiveness risks by setting a common framework across regions and firms. However, designing sectoral agreements could be technically difficult and effectiveness of any agreement will depend on a range of factors:

- The need for multilateral agreement between countries and/or industries
- Whether agreements are legally binding or voluntary: incentives to enter into binding sectoral agreements on a voluntary basis are likely to be weak
- Avoiding product substitution to other sectors which are not covered by an agreement

These barriers suggest that sectoral agreements could be more applicable in sectors which:

- are relatively concentrated: this narrows the scope of an agreement, making multilateral agreement and monitoring more tractable
- have a 'best technology' and/or a role for efficiency standards: this provides a benchmark for which all firms in a sector can aim
- are already internationally regulated or deployed: this avoids having to develop a new multilateral regulatory framework

This is highlighted by existing mechanisms for agreeing sectoral policies in for example shipping and aviation. The Kyoto Protocol specified these should be addressed on a sectoral basis and delegated policy to the international bodies which regulate them; the International Maritime Organisation has recently agreed a global energy efficiency standard for new ships through an amendment to existing pollution legislation.

Sectoral agreements are therefore an opportunity to address competitiveness concerns. If barriers to implementation could be overcome, they could support a global deal but would be unlikely to substitute for it.

Border carbon adjustments

Border carbon adjustments aim to create a level playing field by adjusting for carbon costs embodied in trade.

To address competitiveness risks fully, both imports and exports should be adjusted to create a level playing field between domestic producers and foreign firms:

- **Import adjustment:** carbon regulation on imports based on their embodied carbon emissions (e.g. through a tax on imports or the purchase of emission allowances by importers).
- **Export adjustment:** exporters refunded the carbon cost associated with their production.

Border carbon adjustments could be imposed unilaterally by countries, by blocs of countries (e.g. the EU) or by all countries as part of a global deal to equalise carbon costs (which would ensure all consumption – both domestic and imported – is equally covered). Border carbon adjustments already exist in some emission trading schemes (e.g. California's ETS covers imported electricity).

There would be both domestic and overseas effects from border carbon adjustments:

- By raising the price of imports and reducing the price of exports, border adjustment would encourage consumption of domestically produced goods.
- Pricing carbon on imports gives incentives to overseas producers to minimise their carbon costs by switching to more carbon-efficient production techniques.
- Overseas countries would have incentives to implement their own domestic carbon pricing or export adjustments, so that revenues from the border carbon adjustment accrue to them.

While in principle border carbon adjustments can address competitiveness risks, in practice there are likely to be a range of challenges regarding design and implementation:

- **Legality.** While border adjustments already exist for some taxes (e.g. VAT), and it may be feasible to design a scheme which could comply with WTO trade rules (Box 2.4), a clear answer on the legality of border carbon adjustments is unlikely until a test case is brought.
- **Geopolitical implications.** Border carbon adjustments are politically contentious – as shown by the inclusion of aviation emissions in the EU ETS (this involved regulation of aviation emissions outside EU territory) – and may be seen as an illegal barrier to trade. In addition, it is not clear what impact they would have if implemented outside the UNFCCC negotiation process.

- **Measurement of embodied carbon.** Border carbon adjustments would ideally reflect the embodied carbon in imported/exported products. This is easiest where goods and production processes are relatively homogenous, but even then would require frequent updating and would be open to challenge. Where measurement of embodied carbon is difficult, benchmarks might be used (e.g. applying domestic or global average emission intensity to all imports). However, these will not fully level the playing field to the extent that they diverge from actual intensities.
- **Coverage.** Ideally all internationally traded sectors covered by a carbon price would be subject to the border carbon adjustment. This could impose significant informational and administrative burdens on regulators. Instead, focus could be on only those sectors deemed at risk of significant competitiveness effects.

Box 2.4 : Legal issues and border carbon adjustment

International trade is regulated through the World Trade Organisation's General Agreement on Tariffs and Trade (GATT), as well as through regional and bilateral trade agreements.

Any potential border carbon adjustment would need to demonstrate compatibility with GATT.

The key issues of GATT law to be considered include non-discrimination, indirect/direct taxation, and provision for exemption under Article XX:

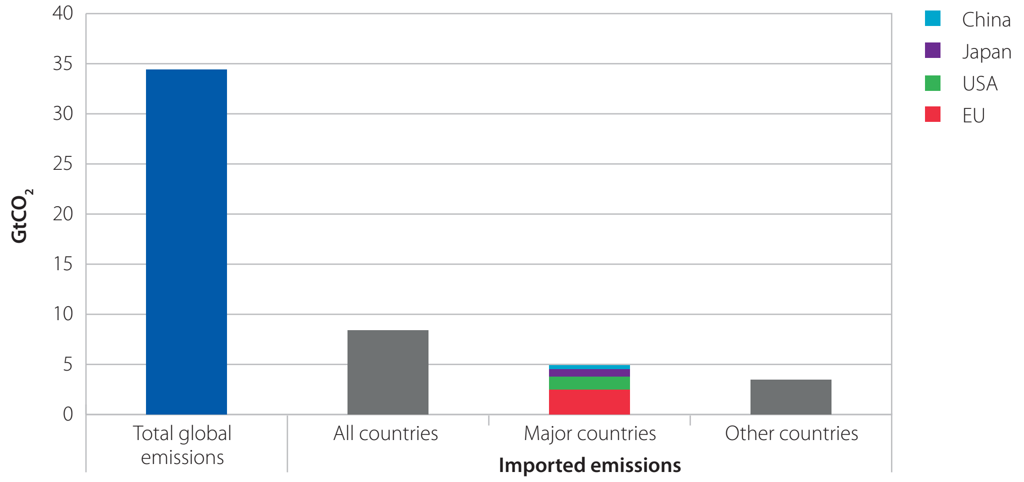
- **Non-discrimination.** Border adjustments to imports must apply equally to all WTO members and must treat imports no less favourably than 'like' domestically produced products.
- **Indirect/direct taxation.** Border adjustments to exports are permitted under GATT for indirect taxes (e.g. VAT) but not direct taxes. It is not clear which category carbon adjustments would fall in.
- **Article XX exemptions.** Border carbon adjustments could potentially be exempted from GATT under Article XX. This allows exemptions 'to protect human, animal or plant life or health', or to conserve exhaustible natural resources.

Compatibility of border carbon adjustments with GATT is unlikely to be resolved until a test case is brought to the WTO. Experience with aviation's inclusion in the EU ETS (which involved regulation of aviation emissions outside EU territory and which is currently paused in order to give space for a global deal to be agreed) suggests that border carbon adjustments could be controversial on both trade and political grounds.

Given limited potential coverage (e.g. traded emissions account for less than 25% of global emissions, Figure 2.9), together with the need for other policies beyond a carbon price, border carbon adjustments are not an alternative to a global deal.

Border carbon adjustments could be useful to address competitiveness risks as a possible transitional measure or where a global deal leads to unequal carbon prices. They are however politically contentious and could have significant ramifications for trade. Therefore while these should not be ruled out, a cautious approach is appropriate (e.g. if border carbon adjustments are to be introduced this should be with the support of blocs of countries rather than unilaterally and in light of a full analysis of possible trade impacts and associated costs).

Figure 2.9: Coverage of traded emissions compared to global emissions (2010)



Source: Eora (2013).
Notes: Traded emissions shown on an import basis for country breakdown. On an export basis the total traded emissions are the same (since imports and exports are equal at the global level) but country breakdown differs in line with trade patterns. Figures are for CO_2 only.

Chapter 3: Competitiveness risks for agriculture associated with the fourth carbon budget

Concerns have been raised by the agricultural industry and the Government that implementation of measures to reduce agriculture greenhouse gas emissions could increase costs and result in loss of competitiveness in this sector. Given the highly traded nature of agricultural products, we assess the extent of potential costs from such measures in the future.

We address two competitiveness concerns:

- **Direct costs** of on-farm abatement in the 2020s to meet the fourth carbon budget, and
- **Indirect costs** to farmers of having to pay more for agricultural inputs such as fertiliser, animal compound feed and electricity due to low-carbon policies (i.e. decarbonisation of the electricity grid).

These are discussed in sections 3.2 and 3.3 below.

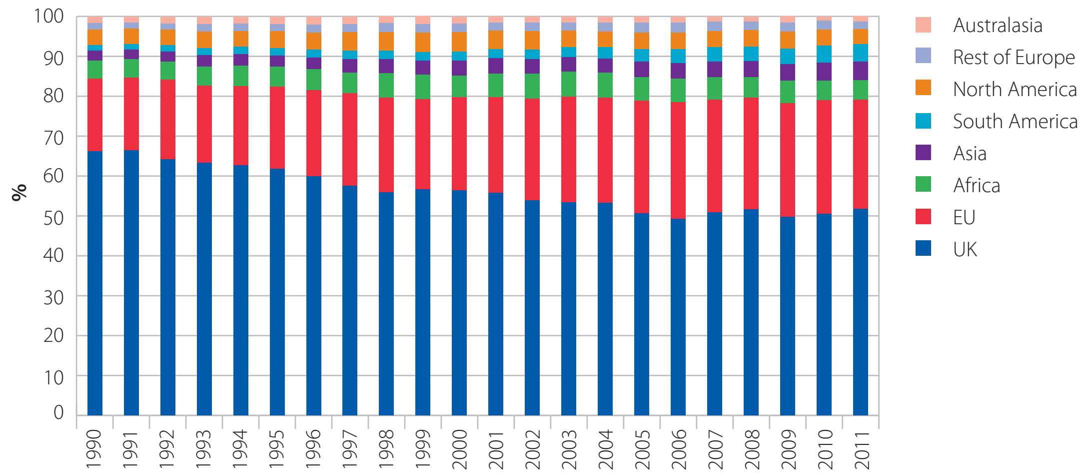
3.1 The environmental and economic significance of agriculture

In this section we put into context the contribution of agriculture to UK GHG emissions and the sector's economic significance (e.g. Gross Value Added, employment and trade), both at the UK and the regional level:

- **Greenhouse Gas Emissions.** Agricultural GHG emissions in 2011 reached 51 $MtCO_2e$, equivalent to 9% of total UK GHG emissions. Most emissions come from agricultural soils (53%) and enteric emissions from livestock (30%), with just 8% coming from combustion.
- **Gross Value Added (GVA).** The agricultural sector is a small contributor to the UK economy, accounting for just under £9bn (0.7%) of UK GVA in 2011. In terms of the value of gross output in 2011, 53% of this came from the livestock sector and the remaining 47% from the output of crops.
- **Employment.** Only 1.5% of the UK workforce (equivalent to 435,000 people) worked in agriculture in 2011.
- **The devolved administrations.** While the share of agriculture to total GVA is similar across England, Scotland and Wales it is more significant in Northern Ireland (1.6% of GVA in 2011). However, employment in agriculture is more significant for the devolved countries than in England and the UK as a whole. For Northern Ireland, 5.6% of the workforce was engaged in agricultural employment in 2011, while it made up 4.3% and 2.6% of Welsh and Scottish employment respectively in the same year.

- **Trade.** Agricultural products are highly traded commodities. The proportion of UK consumption that is met by imports has increased steadily from 34% in 1990 to 48% in 2011[1] (in value terms); with the share of UK production exported less than half of this (Figure 3.1).
  - Over half of all imports come from the EU in value terms, and the EU's share of the UK market has increased from 18% in 1990 to 27% in 2011. In volume terms, import penetration is highest for sugar, fresh vegetables, pig meat and fresh fruit based on a three-year average (2009-11).
  - Over the same period, UK farmers have been exporting more of their produce in value terms; from 12% of UK output to 20% by 2011. In volume terms, exports as a proportion of domestic production are highest for refined sugar beet, fresh fruit, and lamb based on a three-year average (2009-11).

Figure 3.1: Origins of Food Consumed in the United Kingdom



Source: Defra.
Notes: Farm Gate (Unprocessed) Value of Raw Food.

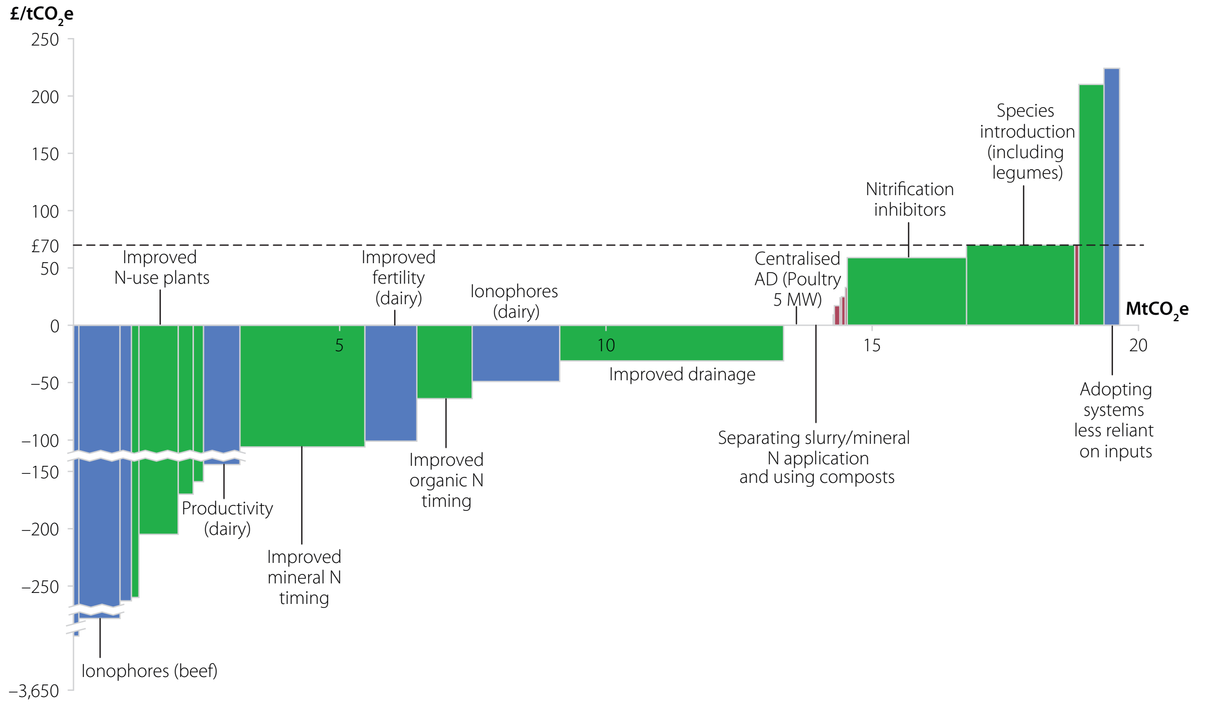
3.2 Costs associated with measures to reduce direct measures in fourth budget

On-farm abatement in the first three carbon budgets

Analysis underpinning the first three carbon budgets suggested scope to reduce UK agriculture emissions by up to 39%[2] from 1990 levels through cost saving measures related to soil and livestock (Figure 3.2). In response, Government set out an ambition to reduce non-CO_2 emissions in the agriculture sector in England by 3 $MtCO_2e$ by 2020. When scaled up to 4.5 $MtCO_2e$ for the UK, this represents about 38% of the maximum potential that we had identified. The mechanism for delivering this ambition for England is via the Agriculture

1 Based on the farm-gate value of raw food.
2 Represents the maximum technical potential.

Figure 3.2: Agriculture MACC maximum technical potential, optimistic case (2022)



Source: Scottish Agricultural College, 2010.
Notes: The optimistic MACC assumes greater applicability uptake, abatement rates and lower costs of abatement for various measures. It also includes measures that would require substantive changes in policies and investment in research and development to support uptake. N = nitrogen; AD = Anaerobic digestion; propionate precursors are feed additives that reduce the production of methane in ruminants; ionophores are feed additives that can improve the performance of cattle and are at present banned in the EU. More details and a full measure list is available in the technical annex of the Fourth Carbon Budget report (2010) on the CCC website.

Industry GHG Action Plan using a voluntary approach based on the provision of information and encouragement.

The on-farm measures to deliver abatement represent cost savings to the farmer, which means that farmers will save money in addition to reducing emissions. For example, measures to increase fertiliser use efficiency by improving the timing of its application will reduce the quantity of fertiliser used, thereby reducing costs while lowering N_2O emissions from soils. Therefore, risks to competitiveness should be very limited.

On-farm abatement in the fourth carbon budget

Analysis underpinning the fourth carbon budget suggested scope to more than double emissions reduction in the 2020s with a further 5.4 $MtCO_2e$ of abatement. While this is mostly achieved through cost-saving measures, a small proportion could incur positive costs of between £9-70/tCO_2e by 2030:

- **New species of nitrogen fixing plants:** applicable for use on a certain proportion of cropland and pasture to fix nitrogen in the soil. This includes varieties not commonly used in the UK at present such as legumes. Combined costs associated with learning, consultancy advice, planting and reduced yields are not fully offset by reduced use of inorganic fertiliser.

- **Anaerobic digestion (AD) on pig farms:** costs are associated with capital investment and delivering lower methane savings than beef and dairy AD; although costs are likely to be partially offset through reduced fertiliser use arising from digestate use.
- **Slurry tank and lagoon covers on beef and dairy farms:** costs are associated with installing new tanks and lagoons with covers due to the difficulty of retrofitting existing storage units.

With the exception of pigs, poultry and protected horticulture which uses less land area, the first measure will affect most farm types directly as almost all of agriculture uses fertiliser (organic and chemical), whether it is applied to land to grow crops or on pastureland to rear livestock. The second and third measures are more specific to the pig and cattle sectors respectively.

These abatement costs total around £80m/year by 2030, which equates to around 1% of UK agricultural GVA in 2011. Overall therefore, the risks to competitiveness associated with on-farm abatement in the fourth carbon budget are expected to be very low. The vast majority of the total non-CO_2 savings of around 10 $MtCO_2e$ by 2030 should deliver cost savings to the farmer.

Policy options to minimise competitiveness concerns in the fourth budget

We should be mindful that policy options selected to deliver abatement in agriculture in the 2020s should not adversely impact competitiveness. In our Fourth Carbon Budget report, we set out a number of options that could be employed to increase abatement. These included amongst other things, the use of voluntary agreements, direct regulation, taxes/subsidies and a cap and trade scheme.

In general, any option that has the effect of increasing production costs relative to goods from overseas competitors would reduce the competitiveness of domestic agriculture. Therefore a tax placed on key farm inputs such as a fertiliser tax or the establishment of a UK-only cap-and-trade scheme on agriculture should be avoided.

This suggests an approach based on the provision of information to farmers about cost-saving measures, possible cost-neutral schemes with stronger incentives at the UK level (e.g. cap and trade with revenue recycling, regulation), and EU-level policies (linking CAP support to implementation of measures to reduce emissions).

3.3 Costs and risks associated with rising electricity prices and other inputs

In addition to the direct costs of on-farm abatement, UK agriculture will also incur higher indirect costs from rising electricity prices due to low-carbon measures. There may also be some increase in costs of other key inputs such as fertiliser and animal compound feed due to low-carbon measures impacting the upstream producers of these products.

The potential costs of indirect low-carbon policies to UK farmers are two-fold:

- **Higher electricity prices** and their impact on farming activities that are electro-intensive (e.g. in-door reared pigs, poultry and dairy).
- **Higher prices for fertiliser and animal compound feed** due to rising electricity prices and direct abatement action undertaken by UK producers of these products.

We look at each of these in turn.

Higher electricity prices

Projected changes in electricity prices for intensive users of electricity

Agriculture is a non-energy-intensive sector, accounting for less than 1% of final UK energy consumption in 2011. About a third of energy consumed is from electricity which is used for a number of activities such as the drying and storage of arable crops, lighting and ventilation for in-door livestock and the pumping of water and nutrients for covered horticultural products.

While the arable sector is the single largest electricity user in English agriculture due to its overall size, there are some parts of the agricultural sector that are as electro-intensive as certain manufacturing sectors, with electricity costs accounting for 10% or more of GVA. These are:

- **Poultry:** electricity bills are 15% of GVA.
- **Pigs:** electricity cost accounts for 13% of GVA (we can expect the proportion to be higher for indoor pigs, which accounts for 60% of the sector, and lower for outdoor pigs).
- **Dairy:** electricity costs are 10% of GVA (Box 3.1).

Box 3.1: Main uses of electricity by the poultry, indoor pigs and dairy sectors

Poultry and pigs: due to strict animal welfare regulations these animals are farmed under controlled environmental conditions in order to minimise exposure to heat and cold stress. In turn, this has positive economic benefits by optimising efficiencies in terms of yield and growth to feed ratio. For example, if pigs are kept below an optimal temperature they will convert more of their food into energy to keep warm as opposed to body weight. Main electricity uses are:

- Ventilation and cooling: neither animal have sweat glands to cool themselves so require properly ventilated housing, which can be natural or electrically powered. Ventilation is also required to remove airborne pollutants.
- Heat: both animals have significant heat demands especially when very young. Newly born piglets born indoors require very high temperatures of around 30°C with the use of heat lamps, and even after 28 days demand is still high. While fossil fuel is mainly used in the poultry sector (e.g. LPG), electricity is the dominant source of heat for pigs.
- Lighting: this is more significant for poultry as light, whether natural or artificial, is needed for broiler growth and to trigger the pineal gland to stimulate egg laying. This is particularly important during the winter months, in order to extend the hours of artificial light to around 14 hours to maintain egg production.

Dairy: in addition to lighting and ventilation, electricity is needed to run the pump machinery in the milking parlour, provide hot water for washing down dairy facilities, and where milk is stored on-farm refrigeration for rapid cooling and storage.

Electricity intensity in these sectors is comparable with many electro-intensive industry players such as rubber (15%) and glass (11%). It contrasts with a much lower proportion in the cereals sector of 3%.

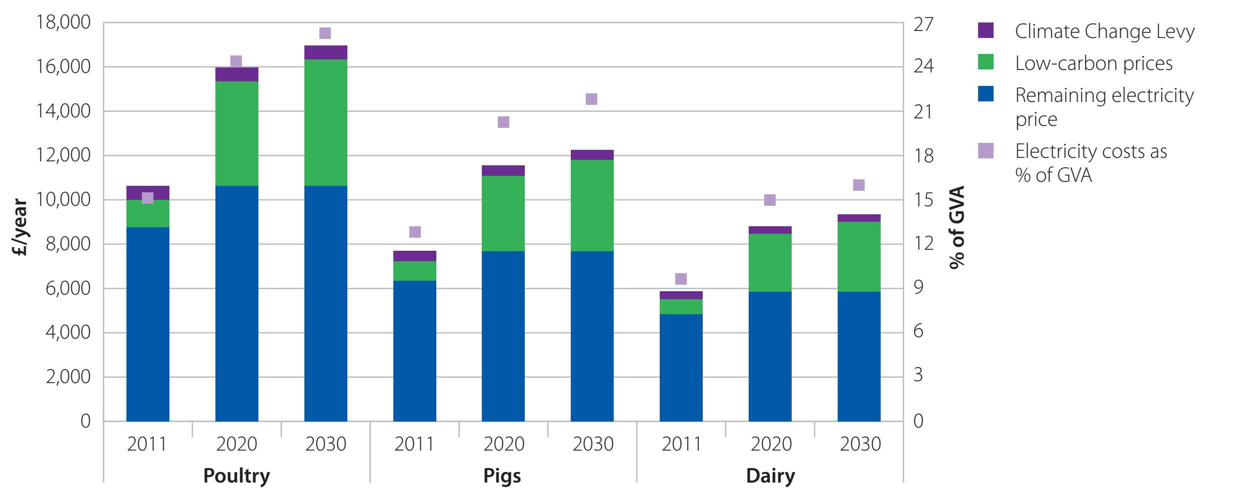
We set out our expectations of the impact of the carbon budgets on future electricity prices in our 2012 report[3]. We assume that electricity prices faced by farmers will rise in line with commercial sector prices (Figure 3.3):

- The electricity price in 2011 for an average size commercial user was 8.50p/KWh. This is expected to increase to 12.9p/kWh (up 50%) by 2020 and 13.7p/kWh (up 59%) by 2030.
- Low-carbon policies account for 12% of commercial electricity prices currently, and this share is expected to rise to 29% in 2020 and 34% by 2030. Low-carbon policies will account for 70% of the increase in electricity prices by 2030.
- Assuming no change in electricity demand, this will lead to a rise in electricity costs as a proportion of GVA to around 26%, 22% and 16% in the poultry, pig and dairy sectors respectively by 2030.

Although these sectors are electro-intensive (electricity costs are a high proportion of GVA), electricity costs are a relatively low proportion of overall costs of around 2%. Therefore the impact of low-carbon measures on the electricity price are expected to be relatively small, potentially raising production costs for these three farming activities in England by around £30m by 2030. This equates to less than 5% of the combined GVA of these activities in England[4] in 2011.

We now assess how electricity cost increases impact the agriculture sector, which depends on the ability of those affected to pass through higher costs.

Figure 3.3: Change in average electricity costs per farm type to 2030



Source: England Farm Business Survey (Defra), Quarterly Energy Prices (DECC) & CCC .
Notes: Assumes no change in value of output over the period. Prices based on average-sized commercial consumer. 2011 average electricity costs based on results that only cover those farms with at least 25,000 euros of standard output in England, which captures 95% of total output in England.

3 CCC (2012) op.cit.
4 Based on results that only cover those farms with at least €25,000 of standard output in England.

Extent of impact of higher electricity prices

The extent to which the competitiveness of UK agriculture will be adversely impacted by higher electricity prices arising from low-carbon policies will depend on:

- The ability of farmers to pass on higher costs associated with higher electricity prices.
- The potential of farmers to substitute away from grid electricity or to use it more efficiently.

Scope for pass-through of higher electricity costs

In the section above, we estimated that low-carbon policies impacting on higher electricity prices would raise farmers' costs by around £30m in 2030 for the three electro-intensive farming activities identified. The extent to which the competitiveness of farmers will be affected will depend on the scope to pass through these costs, which will depend in a large part on the markets' exposure to imports. The higher the level of import penetration (i.e. the greater proportion of domestic consumption that is met by imports), the more exposed domestic producers will be to a rise in production costs relative to main competitor countries. With regard to the markets for pig meat, poultry and dairy products, the domestic pig farmer is perhaps the most vulnerable to competitiveness risks due to an already high level of import penetration, with pig meat imports accounting for 60% of the UK market.

As agricultural products are highly traded, farmers are widely considered to be price-takers[5], with the exception, perhaps, of some niche products. Developments in the domestic pig sector have been cited as an example of loss of competitiveness due to rising production costs relative to competitors (Box 3.2). On this basis, UK farmers would be unable to pass on higher costs of production associated with low-carbon polices that are not incurred by farmers elsewhere in Europe or the rest of the world.

Box 3.2: Impact of unilateral legislation for higher welfare standards on the UK pig sector

In 1999, the UK introduced higher animal welfare standards in advance of the rest of the EU for the housing of pigs by banning the use of sow stalls and tethers. The capital outlay required to comply with the new standards increased domestic production costs relative to main competitors in the EU, such as Denmark and the Netherlands. According to data compiled by the Agriculture and Horticulture Development Board, while the average cost of producing a pig in the UK was on a par with the four main EU competitors before 1999, costs subsequently widened, so that by 2004, UK costs were 11% higher than the EU average, and by 2011 levels still remained higher by 3%.

This legislation was viewed to have been a contributory factor (in addition to unfavourable exchange rates and the outbreak of diseases) to the sharp contraction in the UK pig herd, where numbers have declined by around 40% since 1999. At the same time, cheaper imports saw their share of the UK market increase from just over a third to current levels of around 60%.

As from the start of this year, legislation has extended the ban to the rest of the EU, which should go some way to reducing the gap in pig production costs versus the EU average.

Notes: For more information see Environment, Food and Rural affairs committee (2008) report 'The English pig industry' http://www.publications.parliament.uk/pa/cm200809/cmselect/cmenvfru/96/96.pdf

5 See for example Defra (2009) *'Farming – Resilience and Competitiveness' available at* http://engage.defra.gov.uk/resilience/

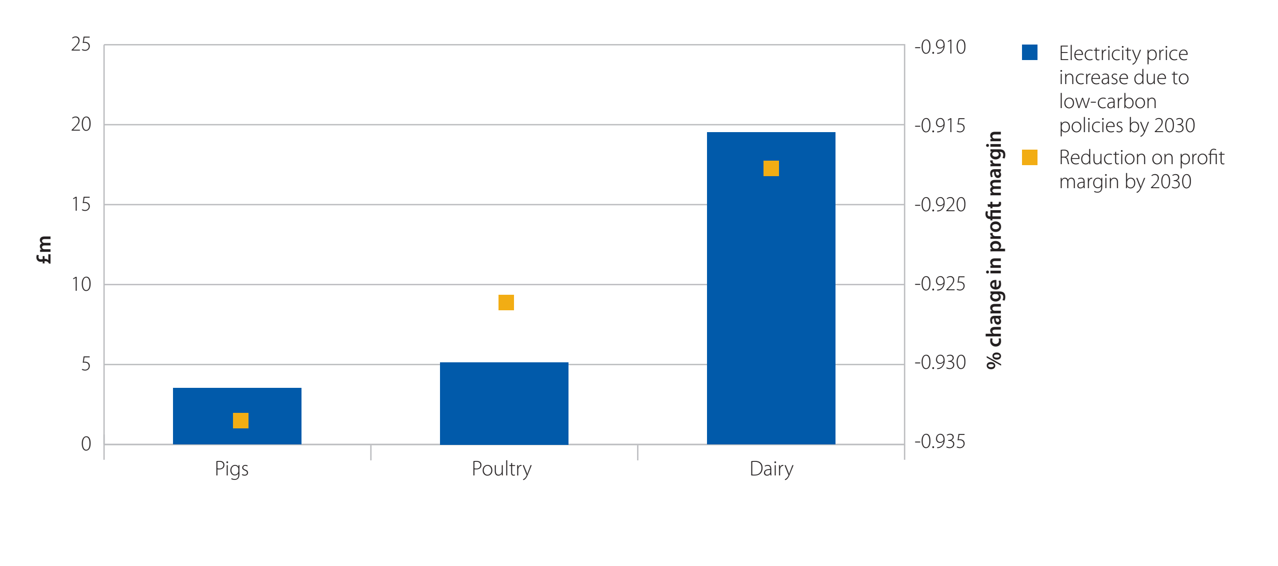
The extent of current cost pass-through is uncertain, but likely to be low, though this could change in the future as non-price considerations become more important to the rest of the supply chain (e.g. better understanding of products' provenance). Nevertheless, electricity costs comprise a small proportion (less than 2%) of total costs so even if no cost pass-through is assumed the impact on profit margins will be marginal, with a decline of no more than one percentage point on average over the period (Figure 3.4).

However, there are likely to be significant distributional impacts reflecting the wide variability of profit levels within each farm sector, with a large proportion of farms making no profit at all. For example, 12% of specialist pig farms and 21% of specialist poultry farms surveyed made no profit in 2010/11 according to Defra's Farm Accounts (Figure 3.5).

Scope for reducing grid electricity demand

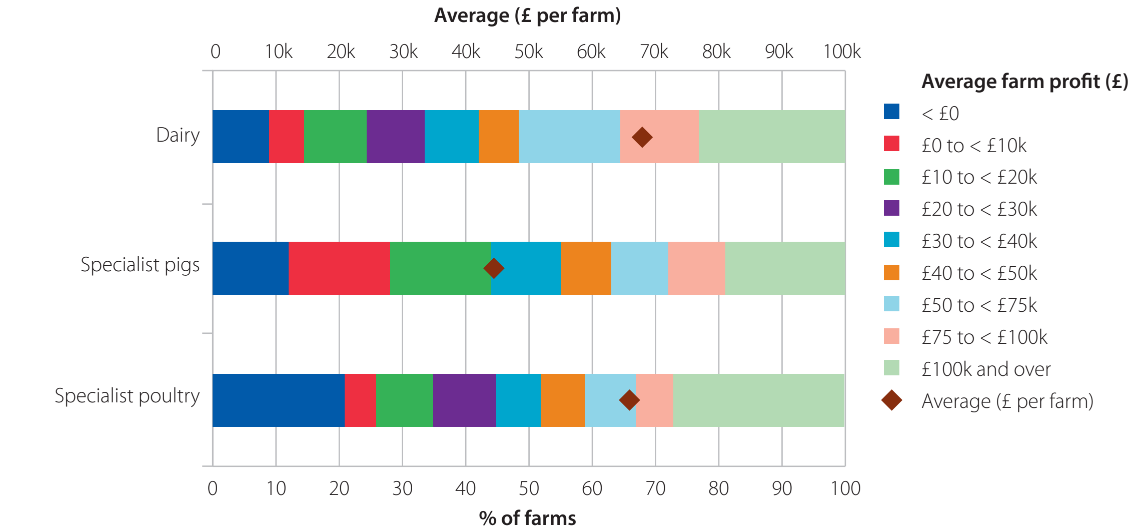
There may also be opportunities to partly offset the rise in electricity prices by reducing grid electricity demand through energy efficiency improvement and using more renewable energy (Box 3.3). An incentive is already provided to pigs and poultry farmers, who are able to qualify for a 90% discount on the Climate Change Levy (CCL) on their electricity bill by agreeing to meet energy efficiency targets. While specific examples suggest significant scope to reduce on-grid electricity demand, the industry-wide potential remains uncertain.

Figure 3.4: Impact of rising electricity prices on profit by farm type by 2030



Source: England Farm Business Survey (Defra), Quarterly Energy Prices (DECC) & CCC.
Notes: GVA as a % of output value is a proxy for profit margin; assumes no change in output value over the period; assume electricity price increase is absorbed by profits thus zero pass-through of costs.

Figure 3.5: Distribution of Farm Business Income (England only, 2011/12)



Source: Defra.
Notes: Farm Business Income is the return to all unpaid labour and to all their capital invested in the farm business including land and farm buildings. For pigs the £10k < £20k band has been combined with £20k < £30k band to prevent disclosure.

Box 3.3: Case studies on reducing on-grid electricity demand

The poultry sector

Noble Foods is the UK's largest egg producer and electricity use is mainly focused on lighting and ventilation for the layers and blast freezing and chilling of chicken meat. In terms of lighting, the company has been rolling out the replacement of all compact fluorescent lamps (CFLs) with LEDs specifically designed for poultry across its sites and those of their contractors. The replacement of every two CFLs, each of 14 watts with one 7 watt LED light has delivered a 75% saving in electricity consumption. With such a large order, Noble were able to negotiate a sizeable discount on the LED price, slashing the payback period to one year. Additional benefits from switching to LEDs are reduced maintenance costs due to their significantly longer life-span, and reduced ventilation requirements due to new lights emitting less heat. Further measures to reduce grid electricity consumption include the installation of small wind turbines, voltage optimisation, PIR sensors and the possibility of using poultry litter in AD in the future.

The indoor pig sector

The building stock of the pig sector is relatively old (on average more than 22 years) which has implications for thermal efficiency of the buildings. Leaky and draughty buildings imply wasted heat, thus action to refurbish or rebuild can significantly cut electricity demand. One Suffolk pig farmer has done both, by refurbishing an existing building (only the steel structures were retained) for its herd of finishing pigs and replacing a 35 year old building with a new one for its herd of five week old pigs. In both buildings, four-inch thick styro-foam was used to insulate the walls and the roofs, which had the effect of reducing electricity use by a quarter in the refurbished building. By having such well insulated buildings, the farmer did not require electrical heating as the heat generated by the pigs alone was sufficient to warm the building. Additional electricity savings were made by having all white plastic surfaces which reduced the need for artificial light while halving the time to pressure wash the building's interior.

The dairy sector

Since September 2012, a Wiltshire based dairy farm has been generating its own electricity from an anaerobic digester capable of producing 4.1 GWh/year, using animal waste mainly sourced from its herd of 500 dairy cows mixed in with farm grown silage. In addition to obtaining free electricity for its own use, the farm will earn an annual income of around £750,000 by selling the surplus to the grid under the Feed in Tariff. Additional savings will also come from use of the surplus heat on farm and from sale to neighbouring facilities in the community, while the digestate is being used to displace about 400 tonnes of inorganic fertiliser each year.

Summary of impact of rising electricity prices

In summary, rising electricity prices due to low-carbon policies could pose a potential competitiveness risk for certain sectors in agriculture (e.g. indoor pigs and poultry). To mitigate these risks, opportunities to offset the impact of rising electricity prices through energy efficiency improvements, use of renewable energy and other innovations should be further assessed.

Impact of other indirect cost increases

Fertiliser and animal compound feed are key agricultural inputs, accounting for around a third of intermediate consumption costs in the sector. For feed, we focus on compound feed only as the processing of raw materials and other ingredients into the final product (e.g. pellets) is energy-intensive. In contrast, alternative feed products such as 'straights' (raw and semi-processed feed) uses much less, if any, energy in their production.

The production costs of these inputs could rise due to low-carbon policies arising from:

- **Higher electricity prices:** Fertiliser production is electro-intensive and prices are forecast to increase by between 34-46% by 2030 as a result of low-carbon measures. However, as a highly traded commodity, we estimate that domestic producers will only be able to pass through 10-20% of the increase in the electricity price due to low-carbon policies. This is expected to result in a marginal increase in prices to farmers of around 0.2-0.5% by 2030. Although electricity is used by the mills to crush and grind raw material feed into pellets, animal compound feed is not classified as electro-intensive as electricity costs comprise less than 10% of GVA. Therefore, additional electricity costs arising in this sector are likely to be limited.
- **Direct carbon abatement action:** Fertiliser producers are subject to the EU ETS and the UK compound feed sector is covered by the Climate Change Agreement (CCA), both of which could entail potential costs. However, allocation of EU ETS allowances for the fertiliser sector will be free to 2020, while the feed sector's 7.5% CCA target for the 2013-2020 period is based on cost-effective abatement. Therefore, neither sector is likely to incur higher costs across the first three carbon budgets. It is less clear however, whether EU ETS allowances for fertiliser producers will remain free beyond 2020, although as mentioned in Section 2 if necessary, potential risks could be addressed under current mechanisms.

In summary, we expect the fourth carbon budget to have a limited impact on final prices of fertiliser and compound feed to farmers arising from a higher electricity price and direct abatement action. Therefore we do not expect these impacts to significantly affect the competitiveness of agriculture.

Glossary

Anaerobic Digestion (AD)
A treatment process that breaks down biodegradable material, particularly wastes, in the absence of oxygen. Produces a methane-rich biogas substitute for fossil fuels and a nitrogen-rich digestate that can be used to displace inorganic fertiliser.

Border carbon adjustment
Policy to create a level playing field for trade by putting a price on imported emissions and/or refunding carbon costs to exporters.

Carbon accounting
The process undertaken to measure and make an inventory of the amount of greenhouse gases emitted.

Carbon budget
The Climate Change Act established a system of five-yearly carbon budgets, currently stretching to 2023-27. They restrict the amount of carbon that can be emitted in the UK during these five year periods.

Carbon capture and storage (CCS)
Set of technologies to capture the carbon dioxide emitted from industrial processes or from burning fossil fuels or biomass, transport it, and store it in secure spaces such as geological formations, including old oil and gas fields and aquifers under the seabed.

Carbon dioxide equivalent (CO_2e) emission
The mass of carbon dioxide emission that would give rise to the same level of radiative forcing, integrated over a 100-year time period, as a given mixture of greenhouse gas emissions.

Carbon footprint
Total amount of greenhouse gas emissions caused directly and indirectly by a nation (equivalent to consumption emissions), a business, a product (equivalent to lifecycle emissions) or a person.

Carbon intense
Activities or goods that have a high emissions intensity (see below).

Carbon intensity
See 'emissions intensity'.

Carbon price
The price at which 1 tCO_2e can be purchased. We use projections for the carbon price as a comparator for judging cost-effectiveness of potential emissions reduction measures.

Carbon price floor
Policy to ensure a set minimum amount is paid for every unit of carbon dioxide emitted.

Climate Change Levy (CCL)
CCL is a tax on the supply of specified energy products (e.g. electricity and gas) for use as fuels that is for lighting, heating and power by business consumers.

Climate objective
To keep central estimates of global mean temperatures as close to 2°C as possible, and to limit the likelihood of temperature change above 4°C to very low levels.

Competitiveness
The ability of firms to sell and increase market share and profitability in international markets.

Contracts for Difference (CfD)
Form of hedging on the future price of a commodity in which a strike price is pre-specified. Payments are made between counterparties depending on the difference between the strike price and the market price at the time.

Conventional gas
Natural gas from conventional reserves.

Direct emissions
Emissions from sources that are owned or controlled by the installation.

Electro-intensive
In this report, taken to be a sector or firm where electricity costs are around 10% or more of gross value added.

Emissions intensity
A measure of total emissions generated per unit of activity. In consumption emissions accounting, typically defined as total emissions per unit of monetary output.

Energy-intensive
In this report, taken to be a sector or firm where energy costs are around 10% or more of gross value added.

European Commission
Executive arm of the European Union.

European Union Allowances (EUAs)
Emissions credits traded within the EU ETS.

European Union Emissions Trading System (EU ETS)
Cap and trade system within the EU covering the power sector, energy intensive industry, and from the start of 2012 all domestic and international aviation.

Feed in Tariff
A type of support scheme for electricity generators, whereby generators obtain a long-term guaranteed price for the output they generate.

Gross Value Added (GVA)
Measure of the contribution to the economy of each individual producer, industry or sector.

Gross Domestic Product (GDP)
Key indicator of the output of the whole UK economy including taxes and subsidies, such that: GDP = GVA + taxes on products - subsidies on products

Indirect emissions
Emissions that are a consequence of the activities of the installation or firm but occur at sources owned or controlled by another entity.

Kilowatt-hour (kWh)
A unit of energy, equal to the total energy consumed at a rate of 1,000 watts for one hour.

Related units are: Megawatt-hour (MWh) = 1,000 kWh, Gigawatt-hour (GWh) = 1,000 MWh and Terawatt-hour (TWh) = 1,000 GWh. The kilowatt-hour is equal to 3.6 million Joules.

Marginal abatement cost curve (MACC)
Graph showing costs and potential for emissions reduction from different measures or technologies, ranking these from the cheapest to most expensive to represent the costs of achieving incremental levels of emissions reduction.

Methane (CH_4)
Greenhouse gas with a global warming potential of 21 (1 tonne of methane emission corresponds to 21 tonnes CO_2e). Arises in the agriculture sector as a result of enteric fermentation in the digestive systems of ruminant animals (e.g. cattle and sheep) as well as in manures. Arises in the waste sector as biodegradable waste decomposes in landfill sites in the absence of oxygen.

Mitigation
Action to reduce the sources (or enhance the sinks) of factors causing climate change, such as greenhouse gases.

Nitrous oxide (N_2O)
Greenhouse gas with a global warming potential of 310 (1 tonne of nitrous oxide emission corresponds to 310 tonnes of CO_2e). Arises naturally in agricultural soils through biological processes and is influenced by a variety of soil and nutrient management practices and activities (e.g. synthetic fertiliser application).

Offshoring
The relocation of a firm's business or processes to a foreign country.

Pass-through rate
The extent to which a rise in firms' costs are passed on to higher product prices.

Renewables
Energy resources, where energy is derived from natural processes that are replenished constantly. They include geothermal, solar, wind, tide, wave, hydropower, biomass and biofuels.

Sectoral agreements
In principle sectoral agreements address competitiveness risks by setting a common framework across regions and firms.

Standard Industrial Classification (SIC)
System for categorising economic activities in the UK by type of activity. At the highest level there are 21 classifications (A-U), including for example Manufacturing (C). These sections are further broken down into divisions, groups, classes and subclasses which are represented in a 2-5 digit hierarchy.

Trade intensity
(Imports+exports)/(output+imports).

United Nations Framework Convention on Climate Change (UNFCCC)
International environmental treaty, signed in 1992, with the objective of stabilising greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

Abbreviations

AD	Anaerobic Digestion
CCC	Committee on Climate Change
CCL	Climate Change Levy
CCS	Carbon capture and storage
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
DECC	Department for Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
EC	European Commission
EU	European Union
EU ETS	European Union Emissions Trading System
EUA	European Union Allowance
EIUG	Energy Intensive Users Group
GDP	Gross Domestic Product
GHG	Greenhouse gas
GVA	Gross value added
kWh	Kilowatt hour
LED	Light-emitting diode
MACC	Marginal abatement cost curve
Mt	Million tonnes
N_2O	Nitrous oxide
OECD	Organisation for Economic Cooperation and Development
ONS	Office for National Statistics
PV	Photovoltaic
RO	Renewables Obligation
ROW	Rest of the world
SIC	Standard Industrial Classification
TUC	Trades Union Congress

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