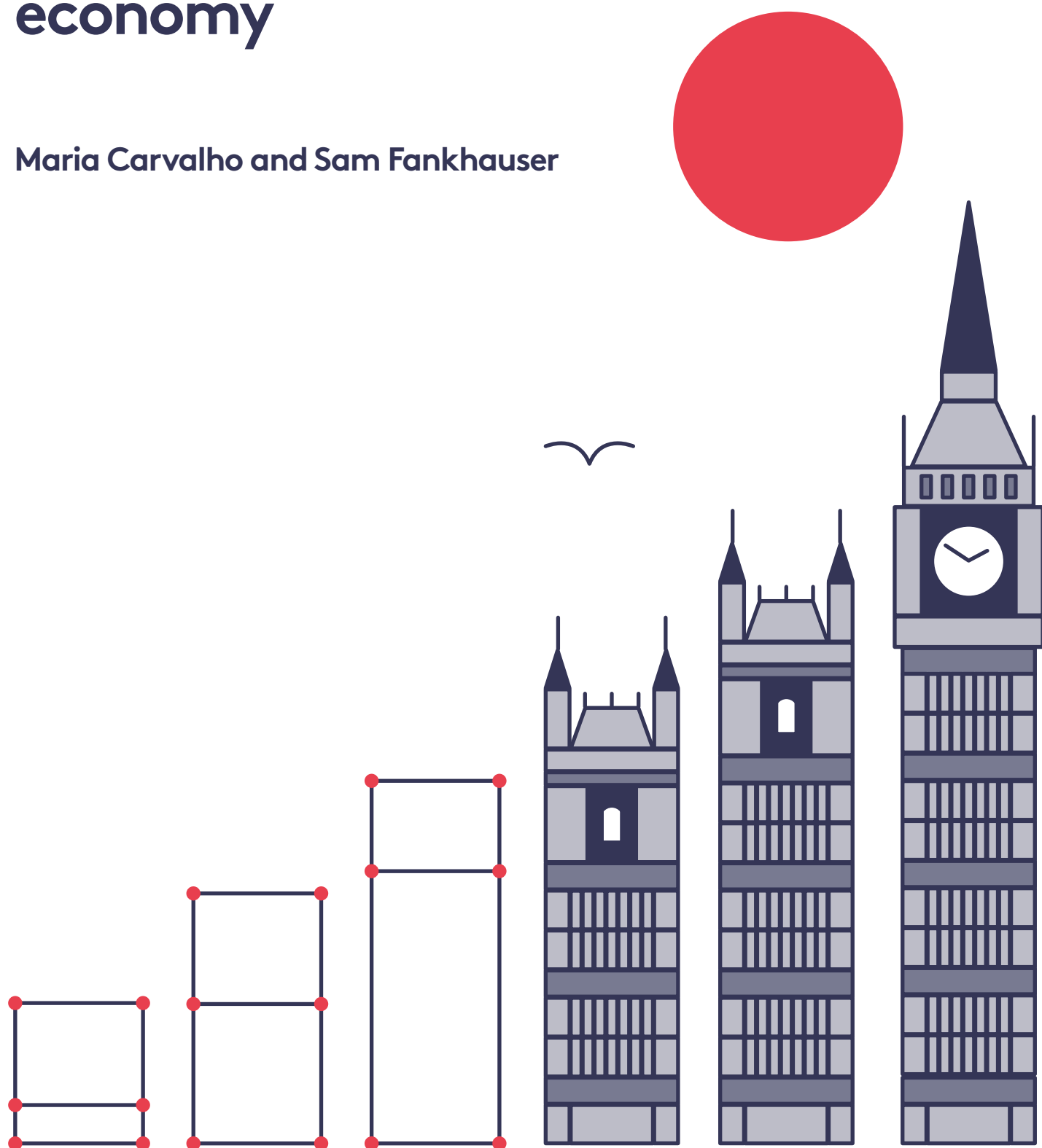


UK export opportunities in the low-carbon economy

Maria Carvalho and Sam Fankhauser



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This policy brief is intended to inform decision-makers in the public, private and third sectors. It has been reviewed by at least one internal and two external referees before publication. The views expressed in this paper represent those of the authors and do not necessarily represent those of the host institutions or funders.

About the authors and acknowledgements

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Executive summary

This policy brief is based on a roundtable discussion attended by representatives from the government, private financial sector, and research community on how the UK can capitalise on global opportunities for low-carbon goods and services, held in London in March 2017. It outlines the opportunities and threats to trade in low-carbon goods and services in the UK, and identifies concrete steps that the government can take now to help UK firms become global leaders in low-carbon trade.

The global low-carbon economy is coming, with opportunities for the UK

The global economy of the future is a low-carbon economy. Under the Paris Agreement 191 countries have agreed to decarbonise their economies and make them more climate-resilient. As countries implement their Paris pledges, there will be expanding export opportunities for the goods and services needed in a low-carbon economy. All major economies are now pursuing

a low-carbon transformation, to the extent that the low-carbon sector is one of the fastest growing parts of the global economy. By 2030 global exports for low-carbon goods and services could be worth £1.0–1.8 trillion a year, seven to 12 times more than today.

The UK is at the forefront of this transformation through its commitments under the Climate Change Act. If the UK wants to be open and outward-looking in the future global low-carbon economy, its exports will have to be low-carbon, too.

Growth opportunities in the UK – and globally – extend beyond technologies specifically identified as low-carbon. The low-carbon economy will encompass all sectors: consultants, lawyers and engineers will offer expertise to drive it; banks will finance low-carbon projects; architects will design low-carbon buildings. Entire supply chains will be reconfigured to enable a more circular economy that is resource-efficient and reuses existing materials. The low-

carbon growth potential thus extends well beyond current market assessments to include not just clean energy but also transport, industry, agriculture, forestry, consumer products and services. This increases the opportunities for UK firms, as many of these activities are key areas of UK comparative advantage, particularly high-value services.

Strong opportunities exist for the UK to increase its low-carbon exports but some areas are at risk of losing market share

The UK is already an effective low-carbon innovator in areas such as electric motors, electricity distribution and domestic appliances, suggested by the data on clean-tech patents. This is encouraging, as the ability of UK firms to compete in the low-carbon economy is a function of their capacity to develop world-leading low-carbon products and services.

The UK has the potential to export other technologies including low-emissions vehicles and batteries. While the UK does not currently have a comparative advantage in these sectors, they are large and rapidly growing markets. Obtaining even a small market share would therefore constitute a substantial export opportunity.

There are threats to current areas of comparative advantage from 'cleaner' competitors. Analysis of clean patents suggests that 13 of the UK's 15 largest industrial sectors – including aircraft and spacecraft, motor vehicles, and steam generators – are less effective than global competitors in low-carbon innovation. This is a concern. While patents are not a perfect indicator of low-carbon innovation (as they ignore, for example, the roles of learning-by-doing and technology adoption), this analysis suggests that large parts of UK industry are at risk of losing market share to cleaner competitors in Germany, Japan and elsewhere.

There are strong low-carbon opportunities in high-value services but they need to be better understood and assessed. Four-fifths of UK GDP comes from services, catering to both domestic and global markets. The UK's natural advantage thus lies in services for a low-carbon economy, including financing for low-carbon projects, climate-risk assessments, legal and consulting expertise on

low-carbon regulations, and software applications that enable the efficient use of resources. How to maximise UK exports of services associated with a low-carbon transition is not yet fully understood. However, it is clear that a highly skilled workforce will be essential in developing innovative services and helping UK services to access global markets.

The UK government has several roles to play in promoting low-carbon trade

The government can help low-carbon firms by offering support for clean innovation and promoting low-carbon solutions at home. Low-carbon innovation has extremely high growth benefits, on a par with those derived from information technology. This justifies government support for clean tech – support that should be provided throughout the innovation process, from research to development, demonstration and deployment. Equally important is a strong, comprehensive set of policies to meet the UK's carbon targets for the 2020s and early 2030s (the fourth and fifth carbon budgets). A coherent low-carbon strategy will not just address carbon-related market-failures: it will also help UK firms to develop globally marketable expertise as part of their response to domestic carbon policies. The Department for Business, Energy and Industrial Strategy (BEIS) will set out

its strategy for the fourth and fifth carbon budgets in its Clean Growth Plan before summer 2017.

The government should make low-carbon exports a priority and aim to secure tariff-free access to international markets. The new Department for International Trade (DIT) has a key role to play in promoting the UK low-carbon sector internationally. Given their potential, low-carbon sectors should be at the core of DIT's export promotion activities and its pursuit of free trade agreements. Specifically, the UK will need to become part of the plurilateral Environmental Goods Agreement (EGA), which is currently being negotiated. The UK will also have to secure free-trade agreements for goods and services, such as low-emissions vehicles, that are not part of the EGA. Low-carbon exports can be further supported through cross-Whitehall initiatives like the Prosperity Fund, which seeks to improve the low-carbon business environment in developing countries, helping their low-carbon transition. The creation of new export markets for low-carbon solutions would be a significant side-benefit.

Specific recommendations

We identify six concrete steps that the government can take now to help UK firms become global leaders in low-carbon trade:

1. **The Department for Business, Energy and Industrial Strategy (BEIS)** should make low-carbon research, innovation and skills a cross-cutting issue of the Industrial Strategy, in order to cultivate world-leading sectors that encourage trade and investment.
2. **BEIS** should devise an effective Clean Growth Plan, consistent with the fifth carbon budget, which allows UK firms to develop expertise for the low-carbon economy, exploit 'home market effects' and become competitive in the global marketplace.
3. **BEIS** needs to carry out more analysis on low-carbon services and assess the opportunities for leveraging the UK's existing advantage in high-value services.
4. **The Department for International Trade (DIT)** should make low-carbon goods and, in particular, services a cornerstone of the UK's international trade strategy post-Brexit.
5. **The DIT** should secure a strong plurilateral Environmental Goods Agreement (EGA) to support free trade in low-carbon goods, complemented by bilateral deals on key sectors not covered by the EGA.
6. **The Foreign and Commonwealth Office, Department for International Development and BEIS** are implementing the UK's commitment to help developing countries in their low-carbon transition. Their efforts could be coordinated with those of **DIT** to advance that transition and create new low-carbon markets.

1. The coming of the low-carbon economy

The global economy of the future will be a low-carbon economy and it is in this environment that UK firms must compete. There is a growing resolve by the international community to address climate change and phase out greenhouse gas emissions over the long term. Across the world, policy-makers at all levels of government are pushing ahead. This includes cities and state governments in the US, where the Trump administration is reversing carbon regulation at the federal level. Technical progress in key low-carbon technologies makes the low-carbon transition both feasible and unavoidable. The low-carbon sector is therefore one of the fastest growing parts of the global economy, creating new opportunities, while the demand for *high*-carbon goods and services will increasingly be constrained, making high-carbon investment increasingly risky.

The context: decarbonisation to meet the Paris Agreement target

The target of the Paris Agreement on climate change, which came into force in November 2016, is to limit the average global temperature increase to well below 2°C above pre-industrial levels, with a more ambitious target of 1.5°C. As part of the agreement, 164 countries (including the European Union as one entity) have submitted Nationally Determined Contributions (NDCs) to the United Nations Framework Convention on Climate Change (UNFCCC). These pledges outline how countries will contribute to the global climate change effort. In combination, the pledges are not yet sufficient to prevent global mean temperatures from surpassing 2°C, but the Paris Agreement includes a 'review and ratchet' mechanism to increase national ambitions over time.

Meeting the Paris climate target requires the decarbonisation of the global economy within the next 50 to 80 years. Global greenhouse gas emissions will have to peak within a decade and decline rapidly thereafter, reaching 'net zero' in the second half of this century (that is, there is a balance between emissions into the atmosphere and their removal into sinks such as forests).

Low-carbon trade shows high global growth potential

Decarbonisation efforts have already started in the electricity sector, but will need to occur in all parts of the economy. It requires an entire systems approach to the way countries organise electric power generation, industrial production, the built environment, transport (from vehicles and trains, to shipping and aviation) and land use.

These transformations will change fundamentally the kinds of goods and services that the private sector will need to provide in future domestic and global markets.

The International Energy Agency (IEA) estimates that US\$3.5 trillion per year globally until 2050, or about double the current level of investment, will be needed to be invested in the energy sector alone to ensure the transition to a low-carbon economy will be path consistent with 2°C of warming (IEA et al. 2017).

The majority of these investments will occur in emerging markets, and in particular China, which is and will remain the largest market for clean energy investment (IEA and OECD 2015). These investments will percolate from the energy sector to the rest of the economy and be mirrored by similar investments in sectors like transport, waste, construction, industrial products, consumer goods and food services. As the markets for low-carbon technologies grow, so does the market for low-carbon services that enable their deployment.

This massive demand creates real export opportunities for goods and services that are low-carbon. Recent analysis by Ricardo AEA (2017) undertaken for the UK Committee on Climate Change estimates that global trade in a selection of low-carbon goods and services could increase from around £150 billion in 2015 to £1.0–£1.8 trillion in 2030, and to £2.8–£5.1 trillion in 2050. This corresponds to an annual growth

rate of almost 10 per cent every year for 35 years. In comparison, global trade in goods and services was around £14 trillion in 2015 (WTO 2016; converted at historical exchange rates).

The low-carbon transition extends beyond low-carbon goods and services

The estimates by Ricardo AEA (2017) are likely to underestimate the true potential for low-carbon trade. They were not intended to be comprehensive, but rather a review of a subset of technologies. Additionally, they are based on a strict but artificial distinction between low-carbon goods and services (LCGS) on the one hand, and conventional goods and services on the other. The LCGS sector is then limited to technologies or services that directly help to reduce greenhouse emissions. Most prominently these include goods such as renewable energy technology and energy efficiency equipment.

In reality there is no strict distinction between the high-carbon economy and the low-carbon economy. The economic changes that are required to combat climate change are not contained to a few sectors. Rather, they are comprehensive and system-wide, to the extent that decarbonisation has been likened to the technological paradigm shifts associated with the industrial revolution or information technology (Perez 2009).

The low-carbon transition therefore extends well beyond those goods and services that can be directly identified as low-carbon. It affects the product mix, production processes and consumption patterns of virtually the whole economy. The low-carbon economy will encompass all sectors, including services and supply chains. It is not confined to individual new technologies, but entails the penetration of new products and processes into existing infrastructures and systems, transforming them from supporting high-carbon to low-carbon activities. The scope for low-carbon goods and services is likely to increase as more individual low-carbon solutions are developed that require complementary system technologies.

Some of the required changes will be small, for example the way in which banks extend mortgages to low-carbon homes. Others will be transformative, either technologically or in terms of business models (or both). Examples include new regulatory arrangements in the electricity market to accommodate intermittent renewable electricity, a new infrastructure for charging electric vehicles, smart appliances and power grids, and monitoring systems for gas networks or land use.

The low-carbon economy also rewards goods and services that are already low-carbon, such as education, entertainment and financial services. The relative price of these inherently low-carbon products will fall relative to the price of high-carbon

goods, which are subject to carbon regulation, making the low-carbon products more attractive to consumers (Hepburn and Bowen 2013). Advances in the creation of a

‘weightless’ knowledge economy will complement and contribute to the low-carbon transition. This is an aspect of the low-carbon economy that remains poorly measured and understood.

Table 1 gives examples of the wider scope for new products, processes and systems that the low-carbon economy may generate.

Table 1. Scope of low-carbon goods and services across economic sectors

Sources: IEA and OECD (2015), The Global Commission on the Economy and Climate (2014), Ricardo AEA (2017)

Sectors	Goods	Systems	Services
Electricity, heat and cooling	- Renewable (solar, wind, biomass, geothermal, marine) - Nuclear generation - Energy storage (including hydrogen and fuel cells) - Co-generation and district heating and cooling - Carbon capture and storage (CCS)	- Smart grid systems (metering, demand response systems) - Hydrogen systems and integration into existing energy infrastructures - Interconnectors - Refurbished electricity lines (including using high voltage direct currents for long distances)	- IT and telecommunications - Financial services - Insurance - Legal services - Engineering services - Information, auditing and consulting services - Architectural, construction and urban design - Retail market services - Natural resource management services
Industry (e.g. iron and steel, metals, cement, chemicals, oil and gas, paper and pulp, pharmaceuticals)	- Technologies that improve the energy and resource efficiencies of production - Substitute for emission-intensive inputs (e.g. renewable generation, or low-carbon alternatives to clinker use in cement) - Energy storage (including hydrogen and fuel cells) - Co-generation and district heating and cooling - Carbon capture and storage (CCS)	- Monitoring and control systems (including for electricity use, and methane monitoring systems for oil and gas) - Waste management systems, including recycling	
Transport	- Electric, hybrid and autonomous vehicles - High efficiency engines and materials use for vehicles, ship, aviation, trains	- Charging points for electric vehicles - Public transport systems (trains, subways)	
Built environments	- Insulation and retrofits (e.g. double and triple glazing for windows) - Low-carbon materials and building methods - Domestic appliances - Distributed renewable energy generation and energy storage - Rainwater harvesting systems	- Smart grid systems (metering, demand response systems) - Resource-efficient systems managing water, sanitation and waste - Flood defence infrastructures	
Land use (agriculture, forestry, green spaces in urban environments)	- Additives to reduce methane from livestock 2nd or 3rd generation biofuels (from agricultural waste)	Land-use monitoring and satellite systems	

2. Low-carbon opportunities for the UK

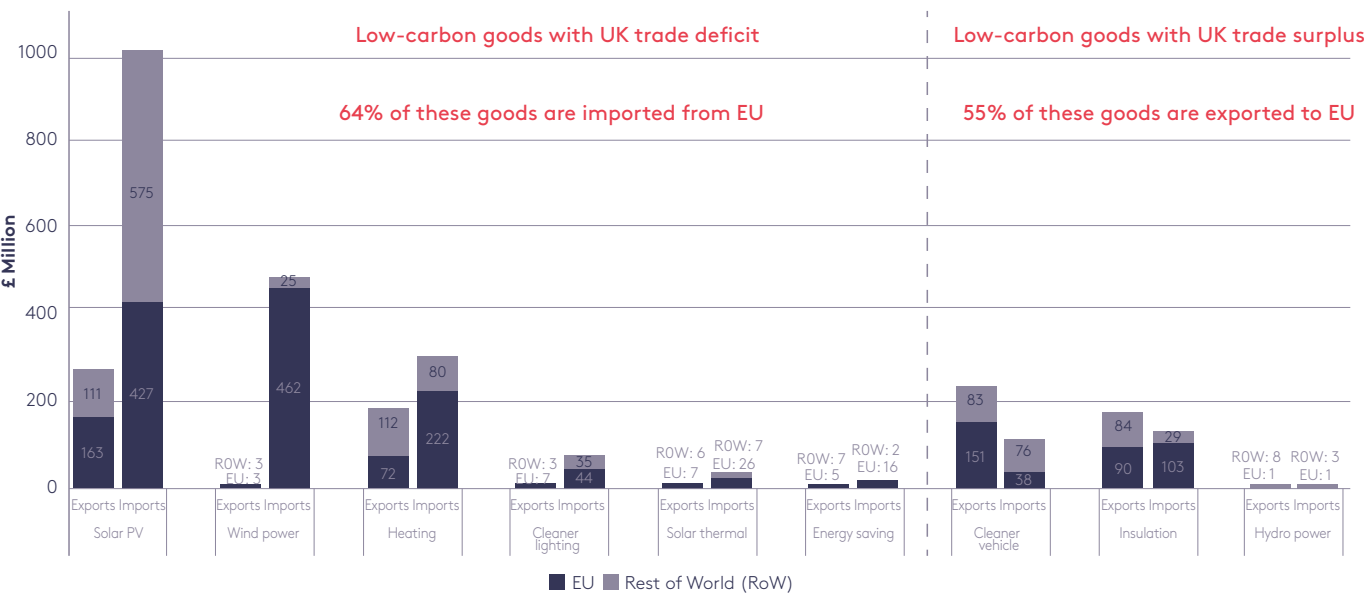
Under the conventional narrow definition of low-carbon goods and services introduced above, the UK's participation in LCGS trade is relatively small, with the export value of the main LCGS sectors in 2015 estimated at between £3.8 and £4.5

billion (Ricardo AEA 2017). The disaggregated trade statistics for low-carbon goods only (excluding services) show a mixed picture of selected comparative strengths but also large import dependencies (see Figure 1). For the major

low-carbon goods the UK has a trade surplus only in low-emission vehicles, insulation and hydropower. By far the most important destination for UK LCGS exports is the European Union, which accounts for 55 per cent of the total.

Figure 1. Current UK imports and exports of low-carbon goods

Source: Dussaux and Carvalho (2017); calculations from UN COMTRADE Data (average trade values from 2011–2014)



It is important to complement this static picture of current trade flows with a more dynamic view of future trade opportunities, which could emerge as the global market for low-carbon goods grows. To do this we draw on earlier

analysis by Dechezleprêtre and Sato (2013) and Fankhauser et al. (2013), who performed a SWOT (strength, weaknesses, opportunities, threats) analysis for trade in low-carbon goods. The methodology is explained in Box 1. It involves

the juxtaposition of current export strengths in different sectors against the ability of these sectors to pivot from the conventional goods and services they currently offer to low-carbon goods and services.

Box 1. SWOT analysis of trade in low-carbon goods and services

Analysis at the Grantham Research Institute (Dechezleprêtre and Sato 2013; Fankhauser et al. 2013) has compared eight leading industrialised economies, including the UK, to assess their strengths, weaknesses, opportunities and threats in the green economy. The SWOT analysis involved for a number of economic sectors the comparison of two indicators, measured on the two axes of a grid.

- The x axis measures current export prowess, or comparative advantage, in a sector. The indicator is calculated by dividing a sector's share of UK exports by the share that sector has globally in world exports (the so-called Balassa indicator). A ratio greater than 1 indicates that the sector is disproportionately important for UK exports and is therefore an area of UK comparative advantage.
- The y axis measures the low-carbon innovation performance of a sector. The indicator divides the share of low-carbon patents in total patents in a UK sector by the same ratio for that sector globally (called the low-carbon innovation index). A ratio greater than 1 indicates that the UK has a disproportionately strong record at low-carbon innovation, suggesting an ability to develop low-carbon products easily.

Putting the two measures together into a grid permits the following interpretation:



The conclusions that can be drawn from this analysis are only indicative and need to be corroborated with detailed sector analysis. In particular, the use of patents as an indicator of low-carbon innovation ignores the fact that switching from high-carbon to low-carbon products and processes is not just a question of fresh patents. It also involves features such as technology adoption and learning-by-doing, which are not captured by the patent data.

Opportunities for new comparative advantages in low-carbon goods lie in sectors such as electric motors and domestic appliances

Dechezleprêtre and Sato (2013) suggest a good potential for new export opportunities in several sectors. According to their analysis, the UK is doing well relative to other countries in sectors such as electric motors/generators/transformers, electricity distribution technologies, and domestic appliances (Figure 2). In none of these three sectors does the UK currently hold a comparative advantage. Their revealed

comparative advantage scores have a value below 1 (i.e. they sit towards the left-hand side of the graphs). However, the high levels of low-carbon innovation suggest that the UK could increase its export share if firms can commercialise their low-carbon know-how and reach scale. This may require either a UK-based industrial partner, or partnering with a foreign firm that has capabilities to scale production (Carvalho 2015).

There are opportunities for export growth even in sectors where the UK may not be a leading innovator. Analysis by Ricardo AEA (2017) suggests such potential exists in energy storage and low-emissions vehicles in particular (Table 2). That analysis also

identifies export opportunities in energy efficiency products, low-carbon energy (including waste-to-energy), waste recovery and low-carbon heat (ibid). Some of these are large sectors with massive potential and securing even a small market share would create substantial export values for the UK.

For example, the Nissan Leaf car plant in Sunderland has the capacity to manufacture 50,000 electric vehicles (EV) a year (Edelstein 2016). Based on individual country targets, the global EV market is set to grow 16 times its current size to 12.9 million EVs by 2020 (IEA 2016). Securing a share of just 4 per cent of this market would be equivalent to hosting 10 Leaf

Figure 2. Sectors in which the UK has export potential for low-carbon goods

Source: Dechezleprêtre and Sato (2013) based on Fankhauser et al. (2013)

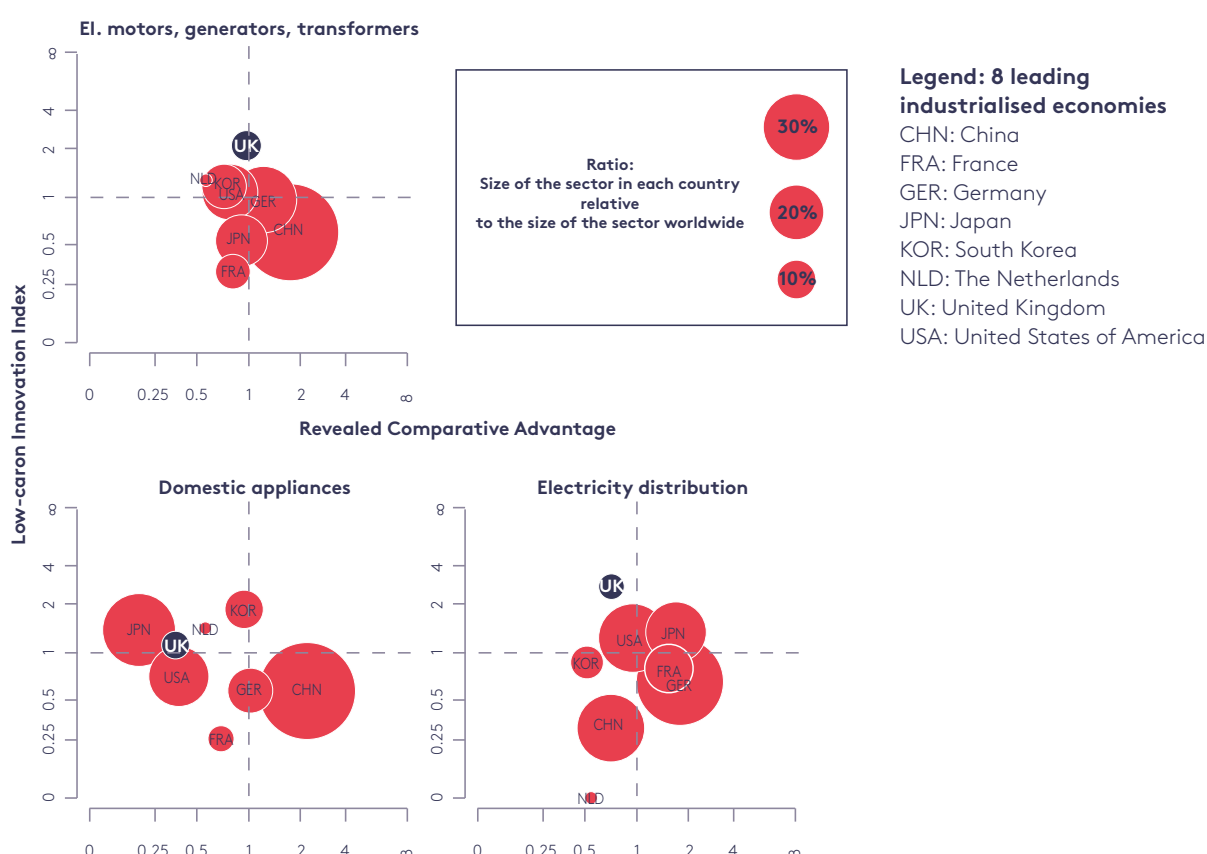


Table 2. UK Export potential for different low-carbon goods

Note: Values are expressed in current (2017) prices.
Source: Ricardo AEA (2017)

Low-carbon goods	2030 Exports (£bn)		2050 Exports (£bn)	
	Low	High	Low	High
Low emission vehicles, infrastructure, fuels cells and energy storage	29.9	68.4	102.6	264.3
Energy-efficient products	17.2	13.3	52.4	37.4
Low-carbon electricity	7.0	26.5	15.7	64.2
Energy from waste and biomass	3.8	20.7	11.7	58.0
Waste processing and materials recovery	0.0	18.8	0	52.7
Low carbon heat	1.0	6.0	3.1	16.8
Total	58.9	153.7	185.5	493.4
% of total UK exports in 2015	15%	40%	48%	127%

production lines in the UK, roughly matching the current output of Jaguar Land Rover in the UK.

Threats exist to current comparative advantages in sectors such as aircraft, engines and motor vehicles

Dechezleprêtre and Sato (2013) also identify industrial goods in which the UK could lose its current comparative advantage. These are sectors that have underperformed in low-carbon innovation and could therefore struggle with the low-carbon conversion.

A striking 13 of the UK's 15 top industrial sectors have low-carbon innovation levels that are lower than those of their global competitors. Figure 3 takes a closer look at three of

them: aeronautical, engines/turbines and motor vehicles. The UK currently has a comparative advantage in all of these (their competitiveness values are above 1), but their records on low-carbon innovation are low (values below 1). This is in contrast to major competitors such as the US (in aeronautics and engines/turbines), Germany and Japan (both in motor vehicles), which are advancing the low-carbon conversion, and to market entrants like China, which is developing a comparative advantage in all three sectors.

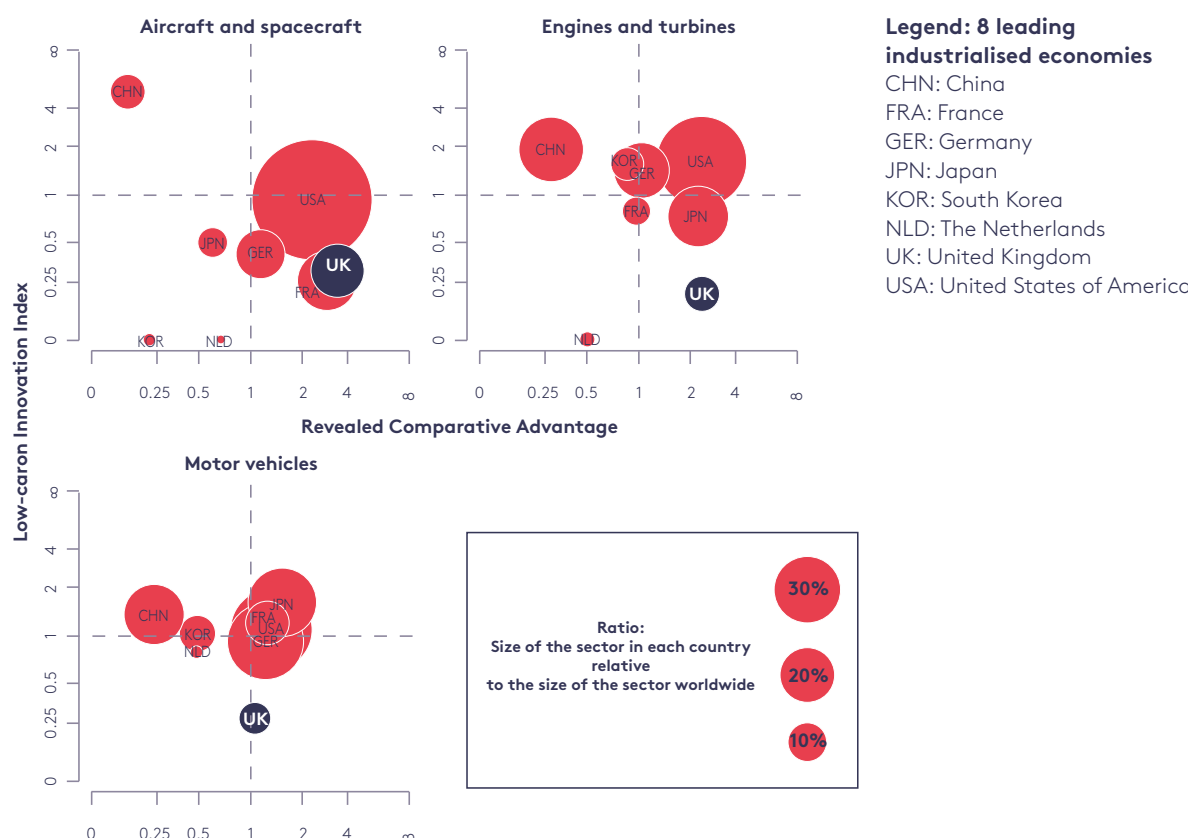
It is worth noting that these statistics probably exaggerate the competitiveness risk in these sectors. Most of them will not rely exclusively on patenting in their approach to low-carbon innovation (the measure used by Dechezleprêtre and Sato; see Box 1). Instead, they may be effective technology adopters

and/or promote innovation through learning-by-doing, for example.

The threats to competitiveness identified here are very different from those that have dominated the debate on the carbon competitiveness of UK industry. There is a long-running debate about the effect of UK carbon policy on the competitiveness of high-carbon industries such as steel. The empirical evidence suggests that while the risk is real, it has probably been exaggerated (Dechezleprêtre and Sato 2014). The government is putting in place safeguards to give high-carbon industries breathing space to prepare for the realities of a low-carbon economy. The concern raised here is that by failing to push the conversion to low-carbon products and processes, some industries are not taking sufficient advantage of that protection.

Figure 3. UK sectors under threat in the low-carbon economy

Source: Dechezleprêtre and Sato (2013), based on Fankhauser et al. (2013)



Export opportunities for low-carbon services are likely to grow as the market for goods expands

The UK is a service economy and much of its export strength comes from the service sector. We know much less about the current and future prospects for low-carbon services than for goods, but the market for low-carbon services is likely to grow in tandem with the market expansion of low-carbon goods. For example, Turner et al. (2013) estimate that: 'By 2020, an anticipated 50% increase in investment in renewables [from 2012 levels] is likely to produce more than a doubling of

spending on risk management services in the sector.'

The services needed to facilitate the transition to a low-carbon economy include those involved with developing and integrating low-carbon goods and enabling the circular economy, along with services that help governments and firms to transition away from a high-carbon economy, including an assessment of climate and health risk (see Box 2).

Ricardo AEA (2017) suggests that the UK is well positioned to provide many of the services listed in Box 2. Britain's leading position in finance, insurance, law, consulting and accounting can be used as a basis to provide services that are specific

for the low-carbon economy. Ricardo AEA (2017) estimates that UK low-carbon services have the potential to grow at annual rates of 12 to 15 per cent in the period up to 2030.

Low-carbon financial services: opportunities and threats

A key area of strength is low-carbon financial services. Low-carbon finance goes beyond developing specialised securities to support low-carbon projects such as green bonds: it engages the entire portfolio of traditional financing mechanisms – from capital markets to project finance, equity finance, conventional bank lending and institutional investing. It requires a systematic assessment of

climate-related risks to financial portfolios and insurance to make appropriate investments to become climate resilient. There are positive signs that the finance industry is undertaking such risk assessments, including *Recommendations of the Task Force on Climate-related Financial Disclosures*, which Mark Carney called for in his role as chair of the Financial Stability Board (Bloomberg 2016; CISL 2016).

However, there is a risk that the UK could lose this longstanding strength to other economies. UNEP (2016) suggests that Paris could become the new international hub for climate finance, given that France was the first country to pass mandatory carbon disclosure requirements for listed companies and to introduce carbon reporting for institutional investors. This may allow French banks to develop

relevant expertise, for example in climate risk assessments.

A policy brief published in parallel to this one, *Financing low-carbon growth and innovation in the UK Industrial Strategy*, outlines key recommendations for the government to strengthen the role of the financial sector in the low-carbon transition (Matikainen 2017).

Box 2. The scope for low-carbon services globally

- **IT and telecommunication services:** software and network infrastructures for the operation of low-carbon goods (e.g. software and networks that enable monitoring, transmission and response of data required for the operation of smart technologies); satellite systems used to monitor land use (e.g. deforestation rates) or leaked/flaring of emissions from oil and gas operations
- **Financial services:** project financing, low-carbon securities, carbon trading, commodity trading for low-carbon goods (e.g. biomass pellets), merger and acquisitions of low-carbon businesses, or access to markets
- **Insurance:** for low-carbon projects and adaptation financing
- **Legal services:** for contracts involving low-carbon projects, or potential litigation services for groups wanting to enforce existing climate-related legislation (e.g. litigation involved in enforcing air quality standards in their constituencies)
- **Consulting, auditing, accounting and information services:** on implementing decarbonisation strategies for businesses or governments, or assessment of climate risks for financial portfolios
- **Engineering services:** installation, operation and maintenance of low-carbon goods; industrial design services; engineering services to build climate-resilient infrastructure
- **Architectural, construction and urban planning services:** design and building of low-carbon built environments, including ensuring climate-resilient transport, water, and sanitation services; design of green spaces in cities
- **Retail market services:** for selling low-carbon goods, including online platforms and branding
- **Natural resource management services:** to enable low-carbon sinks (which can range from services involved with urban parks management to afforestation, reforestation and tourism services); management of rivers and coastal areas against flooding.

3. How the UK government can promote low-carbon trade

There is an important role for government in helping UK firms seize low-carbon opportunities. Government support can be grouped into two broad sets of policies:

1. **Policies that support firms in switching from conventional products and processes to low-carbon products and processes**, including accompanying services. Using the methodology of Box 1, these are policies that help firms move up the y-axis of Figures 2 and 3 by developing low-carbon expertise.
2. **Policies that concern the promotion of low-carbon exports**. In terms of the methodology of Box 1, these are policies that help firms move along the x-axis by developing a stronger export profile.

Below we present six concrete steps that the government can take to help UK firms to become global leaders in low-carbon trade.

Supporting low-carbon innovation

Recommendation 1:
The Department for Business, Energy and Industrial Strategy (BEIS) should make low-carbon research, innovation and skills a cross-cutting issue of the Industrial Strategy, in order to cultivate world-leading sectors that encourage trade and investment.

Investing in science, research and innovation is a key pillar of the government's nascent Industrial Strategy. BEIS, which leads on the issue, will need to make sure that its policies under this pillar provide sufficient support to low-carbon innovation. Support for low-carbon industries needs to be a cross-cutting theme rather than confined to a single pillar. Low-carbon support is required across all sectors, but especially in those that show the greatest promise for new global opportunities and those where

the UK might otherwise lose market share.

Dedicated support for low-carbon innovation is justified not just by the future export potential, but also by the extremely high cross-sectoral growth opportunities that low-carbon technologies generate. Studies of the spillover effects of low-carbon innovation into the wider economy have shown that they are on a par with those in disruptive technologies such as bio-tech, robotics and IT, which are the engines of technology-driven growth (Dechezleprêtre et al. 2016).

Expert studies emphasise the need to provide support through the entire innovation process, from laboratory research to development, demonstration and deployment (e.g. in Dechezleprêtre et al. 2016 and Grubb 2014). British firms and universities are generally considered to do well at the R&D stage, but there are weaknesses in transforming promising research findings into

commercially viable propositions (Grubb 2014). Dechezleprêtre et al. (2016) make specific suggestions of how to boost low-carbon innovation, while Green Alliance (2016) compares current UK policies for the low-carbon economy with those of other countries.

Recommendation 2: BEIS needs to carry out more analysis on low-carbon services and assess the opportunities for leveraging the UK's existing advantage in high-value services.

Fourth-fifths of the value-added from the UK economy is from services, catering to both domestic and global markets. The UK's natural advantage thus lies in services for a low-carbon economy, including financing for low-carbon projects, climate-risk assessments, legal and consulting expertise on low-carbon regulations, and software applications to enable a more resource-efficient and circular economy. Even in the goods sector, firms increasingly combine the sale of equipment with complementary services, such as bespoke design solutions, maintenance contracts and regular product upgrades.

Yet policy-makers have paid much less attention to low-carbon services. The knowledge base is incomplete and basic statistics such as data on the size of the sector are lacking. More analysis will be required to understand how to maximise UK exports of services associated

with a low-carbon transition. One aspect that deserves particular attention is skills. A highly skilled workforce, whether trained domestically or hired internationally, will be essential in developing innovative services and helping UK services to access global markets.

Recommendation 3: BEIS should devise an effective Clean Growth Plan, consistent with the fifth carbon budget, which allows UK firms to develop expertise for the low-carbon economy, exploit 'home market effects' and become competitive in the global marketplace.

The countries that will be the most competitive in the future low-carbon economy will likely be those that have started early on the process of decarbonising their own economies. Their firms will have a head start in developing the technologies and services needed to manage a tight carbon constraint. By exploiting economies of scale and developing low-carbon expertise, these countries will be well positioned to export those services and technologies to markets that have yet to develop similar industries. This is known in the economics literature as the 'home market effect' (Krugman 1980; Hanson and Xiang 2004).

Following the passage of the fifth carbon budget in summer 2016, BEIS is currently finalising its plan for delivering on Britain's carbon targets for

the 2020s and early 2030s. The fifth carbon budget mandates a 57 per cent reduction in greenhouse gases on 1990 levels for the period 2028–2032. The Clean Growth Plan is expected before summer 2017 and will be an important indicator of the government's commitment to the UK low-carbon sector.

The expectations on the government for an effective Clean Growth Plan have been outlined in detail by the Committee on Climate Change (CCC 2015, 2016). Meeting the UK's statutory carbon targets involves dealing with a range of market and behavioural failures (Bowen and Fankhauser 2017). They begin with the need for emitters to face the price of carbon, but also include dealing with barriers related to energy efficiency (e.g. in industry and the residential sector), network effects (e.g. in the roll-out of electric vehicle charging points), barriers in financial markets (e.g. to clean-tech finance) and clean innovation (as outlined above). An integrated approach to environmental policy also recognises the synergies between low-carbon policies and pressing environmental concerns like air pollution.

To give the UK low-carbon sector the chance to thrive, the ambitions in the Clean Growth Plan need to be joined up with those of the Industrial Strategy and recognise the need for a vibrant domestic low-carbon sector.

Promoting low-carbon exports

Recommendation 4: The Department for International Trade (DIT) should make low-carbon goods and, in particular, services a cornerstone of the UK's international trade strategy post-Brexit.

Trade policy and export promotion are gaining in strategic importance as the UK prepares to leave the European Union. Given their growth potential, low-carbon sectors should be at the core of the government's export promotion activities and its pursuit of free trade agreements.

The new Department for International Trade (DIT) thus has a key role to play in promoting the UK low-carbon sector internationally. The starting point must be to secure tariff-free access to international markets. Britain's low-carbon growth potential would be seriously hampered if low-carbon exports were subject to tariffs and non-tariff barriers. Even in the short to medium term, low-carbon trade prospects could be damaged by uncertainty about future trade arrangements.

Recommendation 5: The DIT should secure a strong plurilateral Environmental Goods Agreement (EGA) to support free trade in low-carbon goods, complemented by bilateral deals on key sectors not covered by the EGA.

The UK may benefit from a strong global movement towards free trade in environmental goods (Dussaux and Carvalho 2017). Since 2014, the EU, China, United States, and many other member countries of the Organisation for Economic Cooperation and Development (OECD) have been negotiating a plurilateral Environmental Goods Agreement (EGA). The EGA aims to cut duties on products used in a variety of environmentally-related functions including solar photovoltaics, solar thermal, wind power and energy saving. The UK should push for a strong EGA while it is still a member of the EU and seek to join the agreement once it leaves the Union.

As part of its drive for free trade post-Brexit, the UK should also pursue free trade agreements for goods and services that are not part of the EGA, including products, like low-emission vehicles, that could be of growing importance to the UK economy. This will also enable the UK to import tariff-free low-carbon equipment – for example, offshore wind equipment – to cost-effectively transition to a low-carbon economy. Furthermore, the UK should ensure reduction in trade barriers for services, including for potential non-tariff barriers involved with bundled packages offering the sales of low-carbon goods and services.

Recommendation 6: The Foreign and Commonwealth Office, Department for International Development

and BEIS are implementing the UK's commitment to help developing countries in their low-carbon transition. Their efforts could be coordinated with those of DIT to advance that transition and create new low-carbon markets.

The DIT's efforts are complemented by, and should therefore be coordinated with, cross-Whitehall initiatives like the Prosperity Fund, which seeks to improve the business environment for low-carbon goods and services in developing countries.

The objective of these initiatives is to help developing countries in their own low-carbon transition. They are part of a commitment by the UK and other industrialised countries, reiterated in the Paris Agreement, to provide international climate finance. However, a significant side-benefit of these activities will be the creation of new export markets for low-carbon solutions.

Without jeopardising the primary objective, cooperation across government departments (including DIT, BEIS, the Department for International Development and the Foreign and Commonwealth Office) would help link UK firms with international markets, help them understand international low-carbon needs and advance the low-carbon transition of these markets.

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In this policy brief, the authors outline the opportunities and threats to trade in low-carbon goods and services in the UK, and identify six concrete steps that the government can take now to help UK firms become global leaders in low-carbon trade.

All major economies are now pursuing a low-carbon transformation, to the extent that the low-carbon sector is one of the fastest growing parts of the global economy. The UK is at the forefront of this transformation through its commitments under the Climate Change Act. If the UK wants to be open and outward-looking in the future global low-carbon economy, its exports will have to be low-carbon, too.

The authors assess the growth opportunities in the UK and globally, which extend beyond clean energy to encompass transport, industry, agriculture, forestry, consumer products and services. They identify the UK's current strengths – sectors such as high-value services and areas where the UK is an effective low-carbon innovator – and the threats that exist from cleaner competitors such as Germany and Japan.

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