Department for Business Innovation & Skills

THE SIZE AND PERFORMANCE OF THE UK LOW CARBON ECONOMY

Report for 2010 to 2013

MARCH 2015

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1 Executive Summary

1.1 Introduction

The UK Department for Business, Innovation and Skills (BIS), working alongside the Department of Energy and Climate Change (DECC) and the Department for Environment, Food and Rural Affairs (Defra), commissioned this project in order to gain a clear understanding of the size and performance of the low carbon economy and its contribution to the UK economy.

This report follows on from previous HMG publications in this area, such as the Low Carbon and Environmental Goods and Services report. This new study was commissioned to improve the quality of the data, through running a survey of firms operating in the low carbon economy, and to produce a robust set of metrics on the size and performance of the sector using a transparent, quality assured methodology. It uses a different, narrower definition of the low carbon sector only considering products and technologies which deliver a step change in performance (condensing boilers are excluded, for example). Due to differences in definitions and methodology, results from previous reports in this area are not directly comparable.

The study aims were to:

- Develop a profile, based on a set of clear definitions, of the low carbon economy structured into 24 sectors based on markets and activities. These 24 sectors were then brought together into six broad sector groupings.
- Design a methodology for quantifying the low carbon economy based on this profile.
- Execute the methodology in order to provide data on the economic activity within the sector.

1.2 A definition of low carbon

To aid in reading this report a glossary of terms is included in Appendix II - Glossary.

In this study, the low carbon economy is defined as the activities which generate products or services which themselves deliver low carbon outputs. It does not include the economic activity from the use of these goods and services, except where this represents the primary revenue stream of the operator. Only the portion of a firm's economic activity relating to low carbon goods and services is included, and double counting of economic variables across operating sectors is explicitly avoided. The six sector groupings and 24 low carbon sectors which this study is founded on are;

Table 1: Low carbon sectors and groups

Grouping	Sectors
1. Low carbon electricity[1]	Onshore wind Offshore wind Nuclear energy Hydroelectric energy Marine energy Solar Photovoltaic (PV) Carbon capture and storage
2. Low carbon heat	Geothermal heat Heat pumps Solar thermal Heat networks
3. Waste processing, energy from waste and biomass	Recycling - recovery and reprocessing of materials from waste Generation of energy from waste and biomass. Alternative fuels Biomass equipment
4. Energy efficiency products	Energy-efficient lighting Insulation Energy-efficient windows and doors Heat recovery and ventilation Energy controls and control systems Sustainable architecture and buildings
5. Low carbon services	Low carbon advisory Low carbon finance
6. Other low carbon	Low emission vehicles

1.3 Study method

The low carbon economy is not one that can be studied using the traditional approaches to sector assessment. Definitions of the sector do not map well to Standard Industrial Classification (SIC) codes and many of the firms operating in low carbon also participate in other, non-low carbon sectors (e.g. traditional energy generation, oil and gas and so on).

For these reasons a new, bottom-up methodology was developed. This is founded on three key elements:

- Developing a validated database of the population of firms which operate in the low carbon economy as defined in this study, classifying these firms by the primary low carbon sector they operate in and capturing secondary data on firm activities, size, performance and other characteristics.

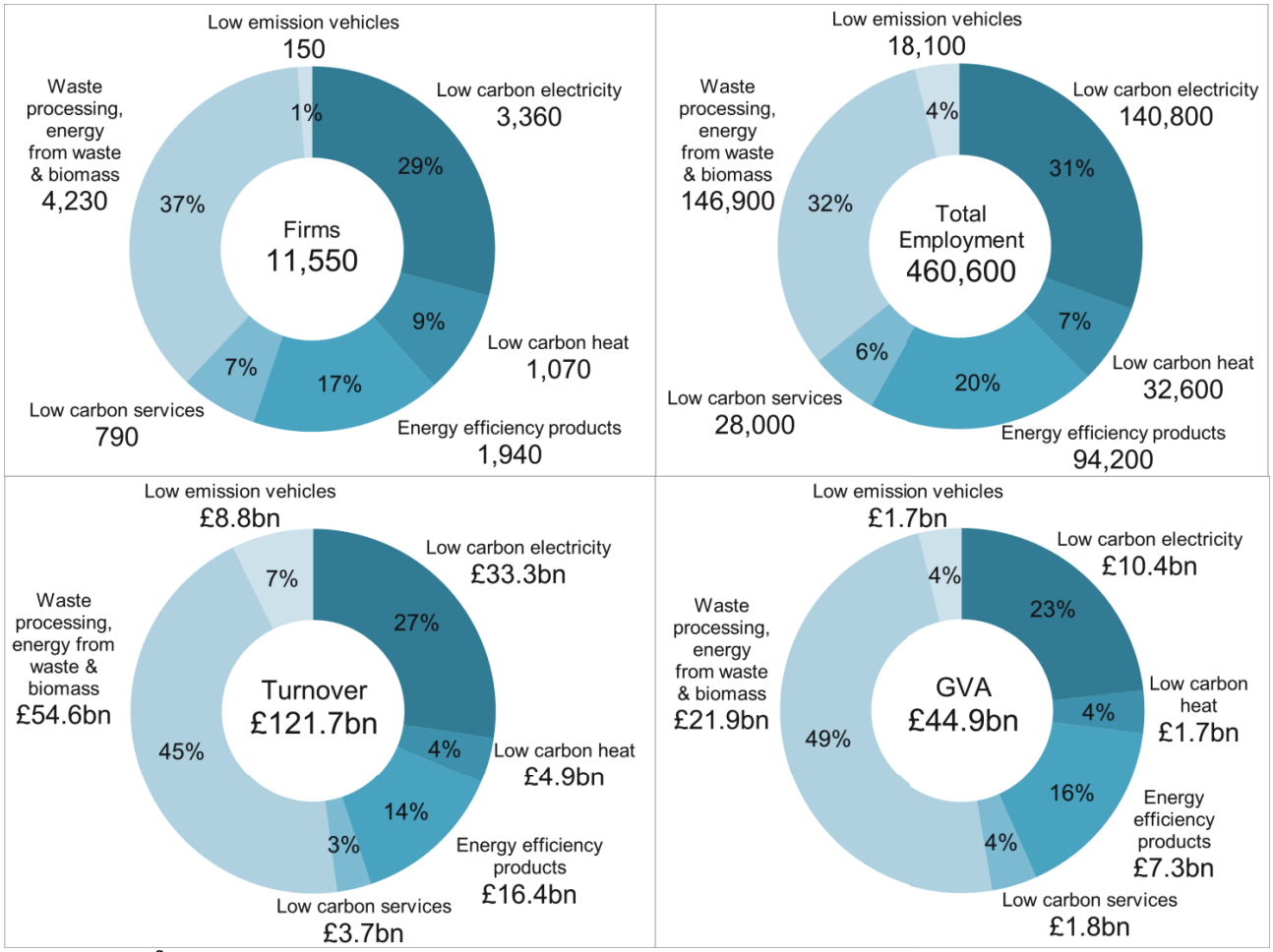
[1] Additional activity relating to electricity from biomass and waste (including anaerobic digestion) is captured in the Waste Procession, Energy from Waste and Biomass group

- Running a survey of firms operating in low carbon sectors to capture data on the extent of participation in each of the 24 low carbon sectors identified, as well as the proportion of activity for the firm in non-low carbon sectors (to understand, for example, to what extent an insulation company is typically involved in solar PV as well).
- Analysis of the population database, using the data from the survey to distribute employment and other economic variables for each firm across each of the 24 low carbon sectors.

The updated approach has a narrower focus than the previous report series which included a wider definition of green sectors. Results from this study are not directly comparable to previous work.

1.4 Summary of key findings

Figure 1: Total Firms, Employment, Turnover and GVA in the low carbon economy and supply chain, 2013



Source: TBR[2]

[2] All data, including that set out in charts is provided by TBR, unless otherwise indicated.

Table 2: Performance and national distribution[3]

Performance	Employment	Turnover	GVA	
Growth 2010-2013	12.0%	24.7%	28.4%	
CAGR[4]	3.8%	7.6%	8.7%	
National Distribution	**England**	**Wales**	**Scotland**	**N. Ireland**
% of Total Low carbon Employment	85.0%	3.8%	9.7%	1.5%
% of all National Employment[5]	1.6%	1.4%	1.8%	0.9%

[3] Data on turnover and Gross Value Added throughout the report is presented in nominal terms.
[4] Compound Annual Growth Rate
[5] ONS, Business Register and Employment Survey (BRES), 2013. The Business Register and Employment Survey (BRES) is the official source of employee and employment estimates by detailed geography and industry. The data used here includes all employment (private and public sectors).

2 Overview of the study

The UK Department for Business, Innovation and Skills (BIS), working alongside the Department of Energy and Climate Change (DECC) and the Department for Environment, Food and Rural Affairs (Defra), commissioned this project in order to gain a clear understanding of the size and performance of the low carbon economy and its contribution to the overall UK economy. The findings of this study provide a robust, comprehensive and repeatable set of results. This study delivers detailed, well-bounded and logical definitions of sectors, technologies and economic indicators.

2.1 Aims and objectives

The UK has committed to a legally binding target of reducing carbon and other greenhouse gas (GHG) emissions by at least 80% by 2050 on 1990 base year levels[6]. A number of strong economic arguments are put forward in support of this move towards a low carbon economy, including:

- Climate change carries with it significant and irreversible long-term costs that can only be mitigated by prompt action.
- The growing dependence on imported fossil fuels carries significant risks in terms of possible geopolitical constraints and price volatility.
- The market for low carbon goods and services is already large and is growing strongly, so represents an area of opportunity for UK industry.

The UK Government is committed, through a number of activities such as the Offshore Wind and Nuclear Industrial Strategies, to creating the necessary conditions for beneficial low carbon growth and for investment by businesses in the low carbon economy. These include providing clarity on the UK Government's approach to the transition to a low carbon economy and establishing clear policy frameworks and strategies. These strategies will have a significant impact on attempts to improve the performance of low carbon industries and enable long-term carbon reduction and certainty for commercial decisions. However, economic data that accurately profile the nature and scale of these sectors are scarce and consequently policymakers' ability to understand their size and growth is constrained.

The "low carbon economy" is loosely defined here as all the economic activities that deliver goods and services which generate significantly lower emissions of GHGs (predominantly CO_2). It is constantly evolving as new activities are conceived or brought to market. Each of these activities involve a number of companies, each employing a number of people that work to produce a quantity of goods and services that are consumed both domestically and internationally.

This study follows on from past HMG reports into the UK low carbon economy, in particular the Low Carbon and Environmental Goods and Services report series (which provided data from 2007/08 to 2011/12). The new study was commissioned to improve the quality

[6] Climate Change Act (2008) http://www.legislation.gov.uk/ukpga/2008/27/contents

and accuracy of the data on economic activity in the low carbon economy. The process of developing a transparent and quality assured methodology was supported through the establishment of a 'Peer Review Panel' chaired by Harry Ziman of PHS Consulting and consisting of colleagues from the Office for National Statistics (ONS), the Committee on Climate Change and the Carbon Trust.

A key methodological difference compared with previous studies is the use of primary data collection, through running a survey of firms operating in the low carbon economy, whereas previous studies relied on using a combination of existing data sources. The value of the survey data is that it provides an understanding of what proportion of activity for firms operating in the low carbon economy occurs in each of the 24 low carbon sectors and what proportion occurs in non-low carbon sectors. As such it can be used to reallocate activity within a database covering the population of firms operating in the low carbon sector, assembled from existing data sources, so that the analysis estimates what activity from these firms actually falls within the 24 sectors identified in the low carbon economy.

Certain sectors included in previous reports that focussed on environmental areas of activity, such as activities to mitigate noise pollution, are not in scope as the focus of this report is only the low carbon economy. The scope of what counts as low carbon has also been tightened. Only products and technologies which deliver a step change in performance have been included. This difference has the potential to reduce the size of the sectors this study measures, in comparison to previous reports.

As with previous reports, data is presented on activity in the UK supply chain which supports the low carbon economy. Whereas other reports have attempted to identify the areas of the supply chain directly, this study uses a standard analytical technique involving ONS multipliers to estimate supply chain activity (see Annex III). It is also worth noting that turnover from electricity generation, where this represents a primary revenue stream of a business, is included within this report.

Due to the differences in definitions, scope and methodology used in this report and the Low Carbon and Environmental Goods and Services report series, figures presented by each are not directly comparable.

This report provides up-to-date, repeatable and robust data on the low carbon economy. These data can be used by analysts and policy makers to deliver evidence to underpin the UK government's environmental and energy policies and will allow the government to support industry to identify and capitalise upon the economic opportunities that emerge.

This study delivers:

- A profile, based on a set of clear definitions, of the low carbon economy and 24 sub-sectors based on markets and activities. These 24 sectors were then brought together into six broad sector groupings.

- A methodology for quantifying the size of subsectors in the low carbon economy based on this profile.

- A quantification of the size of the sector using a transparent set of metrics.

The profile of the low carbon economy provides a clear and transparent description of the markets and activities that make up the low carbon economy. These can be updated as technologies develop and economic forces change.

2.2 Components of the study

The research specification for the delivery of this study contained the following components:

- **To develop a set of clear definitions of low carbon sectors**. The low carbon sectors of interest include both "demand-side" components (e.g. building technologies, low emission vehicles) and "supply-side" technologies (e.g. nuclear power, wind power).
- **To construct a transparent and updateable methodology to estimate the economic activity within those sectors.** The priority for this study was to develop a transparent, quality assured view of a clearly defined "low carbon economy", with a future-proof methodology for providing annual updates. Therefore, it was envisaged that the new analysis would focus on a small number of clearly defined sectors or technologies that contribute to the UK's low carbon economy. These sectors are outlined in Appendix IV - The sectors in more detail).
- **To apply this methodology to obtain a series of quantitative estimates of low carbon economic activity.** The study focuses on delivering analysis of the size and performance of the low carbon economy over the period 2010 to 2013. The assessment covers the following key variables; number of firms, employment, turnover, Gross Value Added (GVA) and business investment[7].

2.3 Methodology overview

The methodology addressed requirements of the brief via the steps set out below. A more detailed description is provided in Appendix III.

Defining the low carbon economy. A detailed exercise was undertaken to establish the key areas of activity that make up the low carbon economy. This involved recourse to previous work, other research and the brief. The brief was explicit in requiring that activities be grouped into demand-led and supply-led activities. For demand-led sectors, only those products and services which had achieved a step change could be included. Those which could only show incremental change, such as many domestic white goods and motor cars, were excluded from the study.

Developing a methodology. A new method for estimating the size of the low carbon economy was needed as the traditional approach using SIC codes was not possible – SIC codes provide a poor match to the low carbon sectors. Furthermore, other approaches suffered from possible double counting, which would overstate the size of the low carbon economy. Thus a firm-based method was adopted.

[7] Business investment relates to investment carried out by businesses to improve productive capacity and is separate to investment undertaken by government, business and consumers to deliver to deliver low carbon infrastructure

Constructing a population database. A list of businesses operating in the low carbon economy was generated by trawling through industry directories, reports and publications. This was reviewed and added to, following suggestions from Government Departments and a review of online directories such as the Microgeneration Certification Scheme. Details of over 20,000 businesses were captured. This was refined and all those businesses, which appeared to operate in the supply chain were excluded. The next step involved matching the businesses to TCR, TBR's own database of firms (see Annex V for further information) and to the IDBR[8]. In order to generate as much insight as possible, branch level and performance data were also captured and imported. The final result was a database comprising 11,500 business units complete with employment, turnover and GVA data for the period 2010 to 2013[9].

Selecting and designing a sample. While the database of businesses provides the population of firms operating in the low carbon sector, it does not indicate the extent to which these businesses are involved. This could only be achieved via a survey. A survey sample was selected that sought to be representative of the population in terms of firm size and low carbon industry sector. A pilot was run and the results analysed. The results indicated that firms were prepared to participate but that the extent of the information that they were either willing or able to provide was limited. This meant that in order to improve response rates the survey was adapted at the expense of collecting data on trade and investment, although estimates of investment were provided using Annual Business Survey data and included in this report. A larger survey generating usable responses from 630 firms was undertaken. While quotas were set, these were determined based on an incomplete knowledge of the sector size. Almost all the sector quotas were met (23 out of 24 sectors). Further work was carried out to achieve a larger sample for the nuclear sector where the quota was not fully met. A significant finding of the pilot, and verified in the main survey, was that businesses tend to operate in more than one low carbon sector as well as in non-low carbon activities. This meant that the survey generated significantly more than 600 data points[10]. A review of survey respondents indicated that large and very large companies were under represented. Work was carried out to address this at a later stage – see below.

Data analysis. The survey data were analysed to establish the extent to which activity in firms is distributed across the 24 low carbon sectors. This was achieved by allocating firms to a single low carbon sector (denoted as their primary sector) and then assessing the level of the firms' employment across each of the 24 sectors. In this way a set of 24 employment profiles was generated, one for each sector, showing for example, what proportion of employment in a company mainly focused on insulation is directed towards solar PV. These proportions were termed coefficients. This approach ensured that double counting was prevented as firms were forced to allocate 100% of their employment to individual sectors (with an additional non-low carbon dummy sector to make up the residual).

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[8] See the Glossary for more about the IDBR and TCR.
[9] GVA data are available directly from TCR, though not from the IDBR. In some cases GVA was estimated based on industry level ratios of GVA to turnover.
[10] As many firms operate in more than one low carbon sector, the number of responses was significantly greater than the number of firms who took part in the survey.

To assess the size of the low carbon economy, the firm population was divided into three groups:

1. Survey respondents.
2. Large companies (that were under represented in the survey) and those for whom more detailed data on their activities could be generated from other sources, e.g. company accounts.
3. The rest of the population that mirrored the survey population.

The data for each group was then adjusted thus:

1. The data for each survey respondent was captured as is, so the application of coefficients was not required.
2. For large firms, the coefficients were not applied, rather efforts were made to investigate them on an individual basis. Examples included; the nuclear power stations operated by EDF, other large utilities generating electricity from low carbon sources and construction companies. This method countered the relatively high representation of SMEs in the survey data and ensured the overall estimate of the size of the sector remained unbiased.
3. For the remaining firms their employment was summed and allocated to the low carbon sectors according to the coefficients within the profiles

The employment profiles were also used to allocate turnover and GVA across the low carbon sectors. It is acknowledged that while employment is a useful proxy, turnover and GVA may not be allocated in exactly the same ratios as employment.

Business Investment. As the survey returned inadequate data on which to make suitable robust estimates of business investment, an alternative approach was adopted. The SIC codes of the firms operating in each primary sector were analysed and used to generate a SIC profile of each low carbon sector. This profile was then applied to data retrieved from the Annual Business Survey to estimate an average level of business investment per employee for each sector, and in turn calculate an estimate of business investment for the sector as a whole.

Historical trends. The low carbon population of firms captured in the database was accurate as of 2013. However, similar population sets for the years back to 2010 could not be generated as there was no way to capture those firms which had ceased trading in the intervening years. However, by using data from TCR, it was possible to identify the cohort of firms that existed in 2010 and were still trading in 2013. The performance of these firms was analysed to establish trend lines. This was judged to offer a best estimate, though it is likely to understate the rate of change as the impact of firm start-ups and closures are not captured and for most low carbon sectors business start-ups, and their economic impact, would be expected to exceed closures.

Estimating supply chain activity. The population database contained only those businesses seen as operating directly in the low carbon economy. The size of the indirect

economy or supply chain was estimated using the established method of applying Type I multipliers, as published by ONS from the supply and use tables[11].

Strengths and limitations. The method adopted is judged to have both strengths and limitations. The key strengths include: using a real world approach based on companies and their activities within the low carbon economy; avoiding double counting by allocating employment, turnover and GVA to specific activities; using verified data sources such as IDBR and TCR to provide totals for employment, turnover and GVA and so preventing over inflation of the sector; adopting a transparent method that allows the data to be challenged; and providing a method that can be replicated in the future, which is both consistent yet able to accommodate change within the individual sectors.

The method and its application in this instance, are also subject to limitations. First, the scale and scope of the exercise were considerably greater than initially anticipated. This resulted in the number of sectors being limited to 24 and the granularity of the analysis being restricted to the level of sector. Secondly, the survey element could be enhanced by increasing the size of the sample to gain wider and more detailed coverage including trade and investment data. Third, the population of businesses may understate the true number of businesses that participate in the low carbon economy, as only businesses that identify themselves as active in low carbon are included. Some businesses, particularly small firms, may operate below this 'radar'. The final limitation reflects that this is the first time that the method has been used. As such trend data are not available other than for 'survivor' firms that have continued to trade over the period. In the future, as new populations are captured, the impact of start-ups and closures can be assessed.

2.4 Results

The key results of the study are set out below:

- A total of 11,550 businesses were directly engaged in the low carbon economy across the UK in 2013.
- Within these businesses, some 269,800 people are employed in low carbon activities, a further 190,800 are employed within the supply chain. This represents 1.6% of UK employment in 2013.[12]
- The low carbon economy generated £70.8bn in turnover in 2013 for those businesses operating *directly* in the sector. This grows to £121.7bn when the supply chain is included.
- The *direct* low carbon economy generated £26.2bn in GVA[13] in 2013, which suggests it is about five times larger than Aerospace, two and a half times the size of Pharmaceuticals, almost twice as big as Chemicals and approximately equivalent to Food and Drink in GVA terms[14]. GVA generated by the low carbon sector increases to £44.9bn when the supply chain is included.

[11] See 10.3Appendix III – Detailed methodology for a more detailed explanation of multipliers.
[12] BRES, 2013
[13] Output is defined as Gross Value Added or GVA.
[14] See BIS, Industrial Strategy: UK Sector Analysis, 2012. Table 2.1, Page 10.

- Businesses operating in the low carbon economy tend to participate in more than one low carbon sector. On average, each business operates in about two sectors out of the 24 within the low carbon economy.
- The low carbon economy has shown significant, year on year, growth over the period 2010 to 2013: employment 3.8%, turnover 7.6% and GVA 8.7%.
- Waste processing, energy from waste and biomass is the largest of the sector groupings across all measures. It is represented by 4,230 firms (37%) and with its supply chain, accounts for 146,900 employees (32%). It generates turnover to the value of £54.6bn (45%) and GVA of £21.9bn (49%).

3 The size and scale of the low carbon economy

This section presents key findings from the analysis of the size and performance of the low carbon sector as a whole. The analysis of the size and scale of the low carbon economy is presented through six sector groupings, each of which is made up of a number of individual sectors. The sector groupings are:

- Low carbon electricity– covers all sectors involved in the generation of electricity from low carbon sources, as well as carbon capture and storage.
- Low carbon heat – this includes all the sectors associated with the production and distribution of heat from renewable sources.
- Energy efficiency products – a broad range of products and services designed to generate additional services from the energy used, primarily associated with the construction and use of buildings. (The incremental improvement of products, and industrial processes to reduce energy consumption while maintaining output has not be included).
- Low carbon services – covers advisory services and low carbon finance.
- Waste processing, energy from waste and biomass – a broad set of sectors involved in extracting value and energy (electricity and heat) from products normally considered as waste and biomass.
- Low emission vehicles – this is put into a separate grouping as it does not fit neatly into any of the others.

The full set of analytical tables can be located in Appendix I - Full data tables.

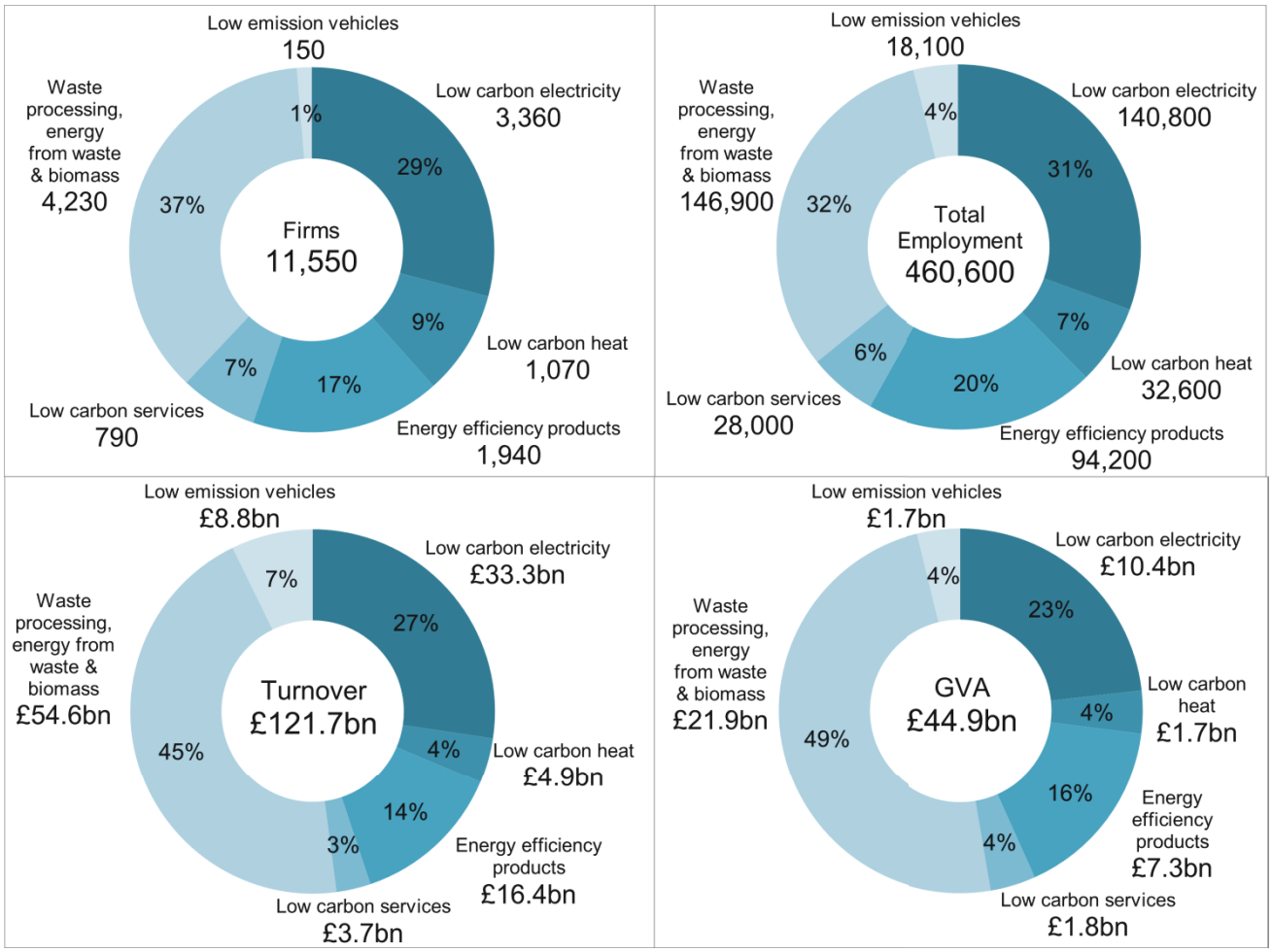
Note that all data have been rounded when presented in table and figures in this report. It is possible, therefore, that individual figures may not sum to the presented totals. The data presented include both direct and indirect activities, i.e. the supply chain, unless marked otherwise.

3.1 Size and scale

- The low carbon economy is defined by 24 sectors which have been assembled into six groups.
- 11,550 businesses were directly engaged in the low carbon economy across the UK in 2013.
- 269,800 people are employed by these businesses, with a further 190,800 employed within the supply chain. This means that a total of 460,600 people work in the low carbon economy once supply chain effects are taken into account.
- Businesses directly operating in the low carbon economy generated £70.8bn sales in 2013. This grows to £121.7bn when the supply chain is included.

- The *direct* low carbon economy generated £26.2bn in GVA[15] in 2013, which means it is about five times larger than Aerospace, two and a half times the size of Pharmaceuticals, almost twice as large as Chemicals and equivalent to Food and Drink in GVA terms. GVA generated by the low carbon sector increases to £44.9bn when the supply chain is included.[16]

Figure 2: Total Firms, Employment, Turnover and GVA in the low carbon economy and supply chain, 2013



Source: TBR[17]

- Businesses operating in the low carbon economy tend to participate in more than one low carbon sector. In fact, on average, each business operates in two sectors within the low carbon economy.
- Many of the businesses working in low carbon also undertake activity in non-low carbon markets. In addition to their low carbon work, they employ 77,800 people, generate £16.4bn in turnover and £6bn in GVA from these other, non-low carbon activities.
- Waste processing, energy from waste and biomass is the largest of the sector groupings across all measures. It is represented by 4,230 firms (37%) and accounts for

[15] Output is defined as Gross Value Added or GVA.
[16] See BIS, Industrial Strategy: UK Sector Analysis, 2012. Table 2.1, Page 10.
[17] All data, including that set out in charts is provided by TBR, unless otherwise indicated.

146,900 employees (32%). It generates turnover to the value of £54.6bn (45%) and GVA of £21.9bn (49%). This is unsurprising given the breadth of the group and the established nature of some of its components, e.g. reprocessing and recycling of waste. Furthermore, as recycling includes domestic waste, this demands an extensive network of collection and reprocessing.

- The generation of electricity from low carbon sources is also substantial and employs 140,800 people. While the number of firms generating electricity at scale is limited, the rise in micro generation (e.g. via solar PV) has supported significant growth in recent years, and this is likely to have led to an increase in the overall number of firms within the group supporting the installation and maintenance of these small-scale installations.
- Low carbon electricity contributes 31% of total employment but only 29% of firms, whereas waste processing makes up 32% of employment and 37% of firms. This indicates that, on average, firms in electricity generation are relatively large, and is consistent with the large capital nature of much electricity generation, e.g. nuclear.
- Energy efficiency products, which has 94,200 employees and a turnover of £16.4bn, includes a wide range of activities, many of which are characterised by large cohorts of small firms, e.g. installers of insulation products.
- Low carbon heat has a significant number of firms who operate across the range of activities covered by the sector group. Firms supplying and installing solar thermal equipment were also very likely to operate in heat pumps, biomass equipment, solar PV and even onshore wind (micro installations).
- Low emission vehicles is a significant group in its own right. While only providing 1% of the businesses, it generates 4% of employment and GVA and 7% of turnover.

3.2 Performance

- The low carbon economy has grown over the period 2010-2013 on all three key measures of employment, turnover and GVA[18].
- In employment terms[19], the low carbon economy has grown by 12% since 2010, with a compound annual growth rate of 3.8%[20].
- All sector groups other than low carbon services have shown overall growth since 2010.
- Low carbon electricity, low carbon heat, waste processing and biomass, and low emission vehicles have all achieved average growth in excess of 3% per annum.

[18] Turnover and GVA are in nominal prices.
[19] Employment is measured as head count.
[20] The data presented here includes activities of businesses working directly in low carbon and the supply chain.

Table 3: Employment – history, including supply chains

Sector grouping	2010	2011	2012	2013	CAGR[21] % ('10-'13)
Low carbon electricity	112,500	127,500	138,000	140,800	7.8%
Low carbon heat	29,300	30,100	31,300	32,600	3.6%
Energy efficiency products	92,100	93,300	93,800	94,200	0.6%
Low carbon services	28,100	27,500	28,200	28,000	-0.1%
Waste processing, energy from waste and biomass	133,400	135,800	140,600	146,900	3.3%
Low emission vehicles	16,100	19,000	18,200	18,100	3.9%
Total low carbon	**411,400**	**433,100**	**450,300**	**460,600**	**3.8%**

Source: TBR

- Total turnover has risen by over 7.6% per annum in the low carbon sector on a compound basis. This rate of increase is significantly above inflation and suggests real growth within this sector of the economy.

Table 4: Turnover (£m nominal) – history, including supply chains

Sector grouping	2010 (£m)	2011 (£m)	2012 (£m)	2013 (£m)	CAGR % ('10-'13)
Low carbon electricity	27,600	29,500	29,500	33,300	6.5%
Low carbon heat	4,200	4,100	4,400	4,900	5.4%
Energy efficiency products	15,900	15,000	15,500	16,400	0.9%
Low carbon services	3,400	3,300	3,600	3,700	3.1%
Waste processing, energy from waste and biomass	39,000	35,000	43,700	54,600	11.9%
Low emission vehicles	7,500	7,700	7,900	8,800	5.3%
Total low carbon	**97,500**	**94,600**	**104,400**	**121,700**	**7.6%**

Source: TBR

- The data demonstrates that the start of the period of review was one of turbulence in that overall turnover fell in 2010 – 2011, and grew strongly in the following two years.
- There was a degree of consistency across the sector groupings despite the change over time. The suggestion is that low carbon is affected by overall macro conditions.
- The fact that electricity generation showed growth in each year may be related to policies aimed at increasing and accelerating the use of renewable and low carbon technologies such as the Renewables Obligation and the Feed-in Tariffs scheme.
- The data on GVA reflects that for turnover with similar patterns across the sector groupings.
- GVA across the low carbon sector has grown at an average compound rate of 8.7% over the period 2010 to 2013. This is one percentage point greater than turnover,

[21] CAGR – compound annual growth rate.

suggesting significant efficiency improvements, and possibly an easing of economic conditions that allow margins to widen.

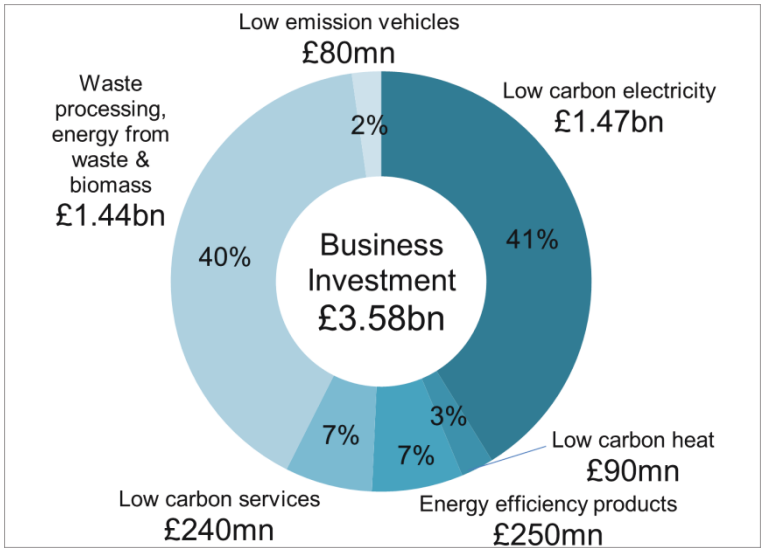
- Waste processing, energy from waste and biomass is pre-eminent, possibly reflecting increasing efficiencies and relatively low input costs. The growth is driven by an increase of 11.9% in waste processing and biomass. Low carbon services and energy efficiency products performed less well. These groups receive fewer direct benefits from incentives, in contrast to electricity generation, heat, biomass and low emission vehicles.
- The turbulence demonstrated in the historical turnover data is also seen in the GVA numbers.
- When GVA and employment data are viewed together (as a proxy for labour productivity) it appears that low carbon electricity has suffered a small fall, low carbon heat remained static and all the others increased. The waste processing, energy from waste and biomass and low emission vehicles groups show significant increases. For low carbon as a whole, productivity has increased as GVA growth outstrips that for employment.
- The data do not provide any indications of the causes of these changes. One might speculate that as technologies mature and economic emphasis changes from designing and producing equipment to operations and revenue generation, that turnover and GVA would increase relatively rapidly while employment remains static or even falls (unless there is a commensurate rise in exports). The marginal fall in the productivity of electricity generation may reflect this as nuclear stations are retired and decommissioned, yet still require substantial labour input. The rise in generation from other low carbon sources is unlikely to have made up the difference in output by 2013.
- The year 2010 – 2011 appears to have been relatively subdued across the whole low carbon economy, but particularly so for energy efficiency products and waste and biomass. The following two years show all groups either being flat or growing.

Table 5: GVA (£m nominal) – history, including supply chains

Sector grouping	2010 (£m)	2011 (£m)	2012 (£m)	2013 (£m)	CAGR % ('10-'13)
Low carbon electricity	8,800	9,100	10,100	10,400	5.8%
Low carbon heat	1,500	1,500	1,600	1,700	3.7%
Energy efficiency products	7,000	5,900	6,200	7,300	1.5%
Low carbon services	1,800	1,700	1,800	1,800	0.9%
Waste processing, energy from waste and biomass	14,500	13,300	17,300	21,900	14.7%
Low emission vehicles	1,300	1,300	1,600	1,700	8.7%
Total low carbon	**35,000**	**32,900**	**38,600**	**44,900**	**8.7%**

Source: TBR

Figure 3: Business Investment in the low carbon economy, 2013



Source: TBR

- In 2013, firms in the low carbon economy invested £3.58bn in their businesses. Capital equipment and R&D were the key targets for investment[22].
- Business investment in low carbon electricity and waste reprocessing, energy from waste and biomass were an order of magnitude greater than in any other sector group[23].

3.3 Spatial distribution

- England is home to 85% of all employment in the UK's low carbon economy which is comparable to the proportion of all UK employment.
- Scotland is marginally over represented across the low carbon economy as a whole, both in terms of absolute employment and percentage of all employment. The low carbon economy represents 1.8% of all employment in Scotland, which is the highest national figure.

As measured by the proportion of the total workforce engaged in each of the low carbon sector groups, we can see that the countries in the UK demonstrate areas of relative strength:

  - Scotland is strong in low carbon electricity.
  - England is strong in low emission vehicles.
  - Wales is strong in energy efficiency products.
  - Northern Ireland is strong in waste processing, energy from waste and biomass.

[22] Time series data are not available for business investment.
[23] Investment by businesses in some parts of the low carbon economy is particularly lumpy, e.g. building of a new power station, offshore wind farms or an energy from waste plant. This will exacerbate any sampling error, so caution is advised when using these data.

Table 6: Total employment by country, 2013, including supply chain

Sector grouping	England	Wales	Scotland	Northern Ireland	UK
Low carbon electricity	113,600	4,200	21,500	1,400	140,800
Low carbon heat	25,800	1,300	5,000	500	32,600
Energy efficiency products	82,200	6,800	4,500	700	94,200
Low carbon services	23,800	700	3,400	100	28,000
Waste processing, energy from waste and biomass	130,600	4,000	8,700	3,600	146,900
Low emission vehicles	15,600	400	1,700	400	18,100
Total low carbon	391,700	17,300	44,800	6,800	460,600
% of all national employment in low carbon[24]	**1.6%**	**1.4%**	**1.8%**	**0.9%**	**1.6%**

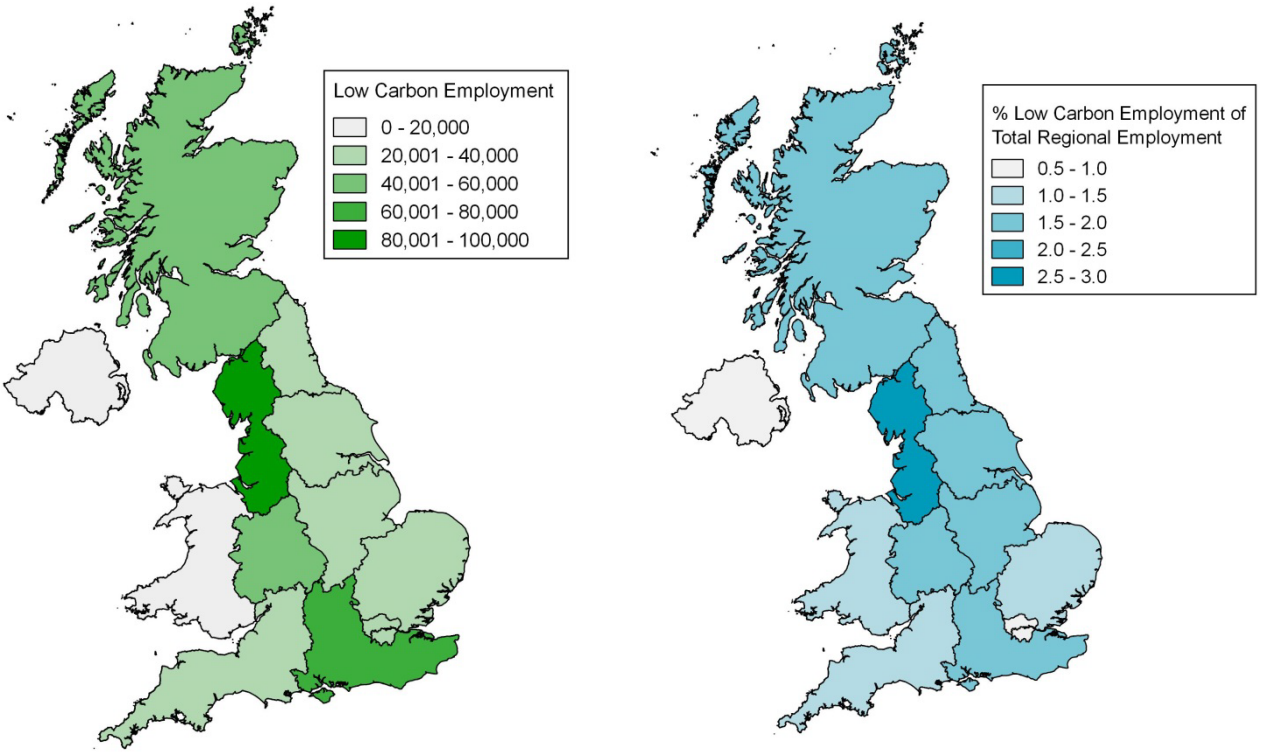
Source: TBR

The full regional analysis by low carbon sector, provided in Appendix I - Full data tables, supports the following findings;

- The North West has, by far, the largest involvement in electricity generation reflecting the presence of nuclear (generation, decommissioning and fuel re-processing).
- The concentration of manufacturing in the West Midlands is reflected by the area's strengths in low emission vehicles and energy efficiency products. The South East also scores highly as a result of vehicle production.
- London show strengths in services as well as waste and biomass, the latter possibly being a reflection of headquarters' activities.
- The second highest concentration of activity relating to low carbon electricity is in the South West. This is due to the number of nuclear power stations (operating, in decommissioning and planned) within the region.

[24] BRES, 2013

Figure 4: Regional and national distribution of employment, 2013



Source: TBR

4 Low carbon electricity

This section presents key findings from the analysis of the size and performance of the Low carbon electricity sector grouping. Low carbon electricity is one of the largest groups and includes strategically important infrastructure. The sectors that make up the Low carbon electricity grouping are:

- Onshore wind
- Offshore wind
- Nuclear energy – incorporating; new build, current operations and decommissioning and dismantling
- Hydroelectric energy – large and small installations
- Marine energy – incorporating wave and tidal stream, tidal range and wave power
- Solar photovoltaic (solar PV)
- Carbon capture and storage (CCS)

The full set of analysis can be located in Appendix I - Full data tables.

Electricity from biomass and waste is not included here. The constraints of the project have required a degree of aggregation preventing the separation of waste and biomass, and of electricity and heat. Given this, and the significant overlap with waste processing, this sector has been included in the waste processing, energy from waste and biomass group. It is acknowledged that both waste and biomass are significant fuels for the generation of both electricity and heat, either separately or through combined heat and power plants (CHP).

Note that carbon capture and storage (CCS) is included in this grouping, despite the fact that, at present, its principal application is with industrial processes, rather than electricity generation. There is no full scale example of CCS in use on power stations in the UK as yet, though two demonstrators are in development: White Rose and Peterhead. Activity from process industries which separate out carbon as part of the production process and the use of carbon in Enhanced Oil Recovery could be seen to be part of the wider CCS economy once transport and storage infrastructure is in place. For this reason, they have been included in CCS, even though no full chain of activities exists at present.

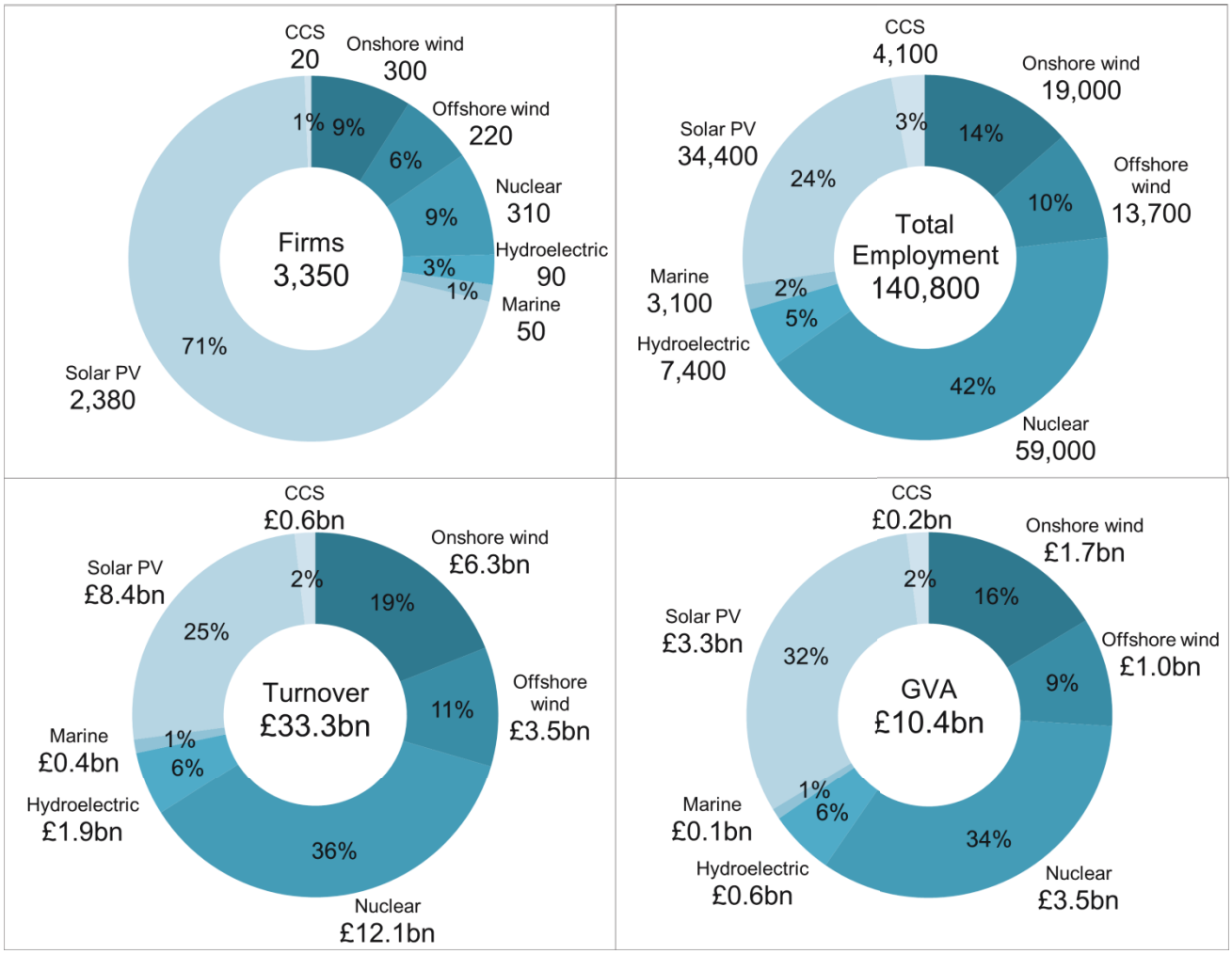
4.1 Size and scale

- Low carbon electricity is one of the larger sector groupings with 29% of firms, 31% of employment, 27% of turnover and 23% of GVA. It is represented by 3,350 firms and contributes 140,800 employees when the supply chain is also taken into account.
- Turnover generated by low carbon electricity was £33.3bn in 2013 and this delivered a GVA output of £10.5bn.
- Solar PV dominates the group in terms of firm numbers. This is a function of the large number of small firms involved in supply and installation. However, this is not reflected in the distribution of employment across sectors. Solar PV provides 24% of employment within a firm base which represents 71% of all businesses in the low carbon electricity grouping. This indicates that the average firm has few staff directly employed on work related to solar PV, although there is likely to be a small number of

larger firms who are beginning to specialise. Nuclear shows an alternative pattern with 42% of employment and only 9% of the firms, reflecting that a degree of critical mass is required to operate in the sector. Onshore and Offshore wind, to a lesser extent, demonstrate similar structures where the average firm size is relatively large.

- Interviews with firms operating in these sectors indicated that government policy and subsidies are likely to have had an impact on demand and hence employment. Firms noted that in future years the introduction of contracts for difference and changes to planning may influence investment and employment.
- For solar PV, any reduction in subsidies, e.g. via feed-in tariffs, may have largely been offset by a fall in the price of equipment. The net effect has been that the overall cost-benefit for domestic users/investors has remained relatively unchanged according to interviewees.

Figure 5: Firms, Employment, Turnover and GVA in low carbon electricity and its supply chain, 2013



Source: TBR

4.2 Performance

- Marine technologies and carbon capture and storage have experienced the lowest rates of employment growth over the period. These sectors have yet to achieve the degree of commercialisation of other sectors such as wind or solar PV. Firms contacted indicated that they were still in the development and proving phase and yet to fully achieve revenues from trading[25].
- Nuclear has shown some employment growth. At present, the majority of employment within the sector is based in the operation of existing plant (including the fuel cycle) and decommissioning and dismantling. The major expansion of the workforce associated with new build has yet to take place.
- All other sectors have shown low to mid, single digit growth in employment other than solar PV and onshore wind which have experienced compound growth rates of 20.8% and 10.0% per annum respectively. Enhanced technology, reduced capital costs as well as subsidies have been cited as reasons for this rapid growth.
- The solar PV sector has experienced unprecedented growth during the period and the methodology allows much of this to be identified. However, it is likely that the true expansion could be even higher - increased specialisation of firms in solar PV and the entry of many new firms would likely account for even higher growth in the sector. These estimates may understate total growth in the sector and may not fully reflect the low base the UK solar PV sector has built up from since 2010.
- The low carbon electricity group appears not to have suffered the effects of global recession in the way that the low carbon economy as a whole has. The year 2010-2011 returned positive employment growth, with only carbon capture and storage showing a small decline. The two subsequent years were relatively muted in terms of employment change, though no sector contracted between 2011 and 2013.

Table 7: Low carbon electricity – employment history, including supply chain

Sector	2010	2011	2012	2013	CAGR % ('10-'13)
Onshore wind	14,300	17,800	18,400	19,000	10.0%
Offshore wind	10,900	11,600	12,400	13,700	8.0%
Nuclear energy	54,000	55,100	57,400	59,000	3.0%
Hydroelectric energy	6,800	7,300	7,100	7,400	2.9%
Marine	3,000	3,100	3,000	3,100	1.5%
Solar PV	19,500	28,800	35,600	34,400	20.8%
Carbon capture and storage	4,000	3,900	4,000	4,100	1.2%
Low carbon electricity	**112,500**	**127,500**	**138,000**	**140,800**	**7.8%**

Source: TBR

- The order of the sectors within the group remains unchanged when looking at turnover. Looking forward, the relative attractiveness of onshore wind as an investment may be impacted by a variety of factors including changes in planning and political uncertainty.

[25] A major business in marine has subsequently gone into administration.

- Turnover from offshore wind and nuclear are expected to increase as additional capacity comes on stream, though this will take time. Turnover for solar PV primarily reflects the sale and installation of equipment rather than operations. Furthermore, any revenues generated by households from feeding into the grid are unlikely to be captured.
- All sectors within the group, except carbon capture and storage showed positive growth in turnover.

Table 8: Low carbon electricity – turnover (£m nominal) history, including supply chain

Sector	2010 (£m)	2011 (£m)	2012 (£m)	2013 (£m)	CAGR % ('10-'13)
Onshore wind	5,400	7,000	5,700	6,300	5.3%
Offshore wind	3,300	3,100	3,100	3,500	2.5%
Nuclear energy	10,200	10,700	11,500	12,100	6.0%
Hydroelectric energy	1,700	1,900	1,800	1,900	4.5%
Marine	400	300	400	400	5.5%
Solar PV	6,000	5,400	6,200	8,400	11.9%
Carbon capture and storage	700	1,000	800	600	-3.4%
Low carbon electricity generation	**27,600**	**29,500**	**29,500**	**33,300**	**6.5%**

Source: TBR

- The performance of the low carbon sector differs when GVA is examined. Whilst most sectors grew their GVA over the period 2010 to 2013, two became less productive; hydroelectric and carbon capture and storage. For hydro this is likely to reflect the lack of any new large hydroelectric facilities, as all the major natural facilities have been exploited. Industry commentators noted that new business investment is in small scale schemes, many of which are used by organisations that consume the electricity themselves and only sell excess capacity to the grid. This certainly seems to be reflected in the investment data, where at £30m, it was responsible for the smallest capital commitment within the group (alongside marine).

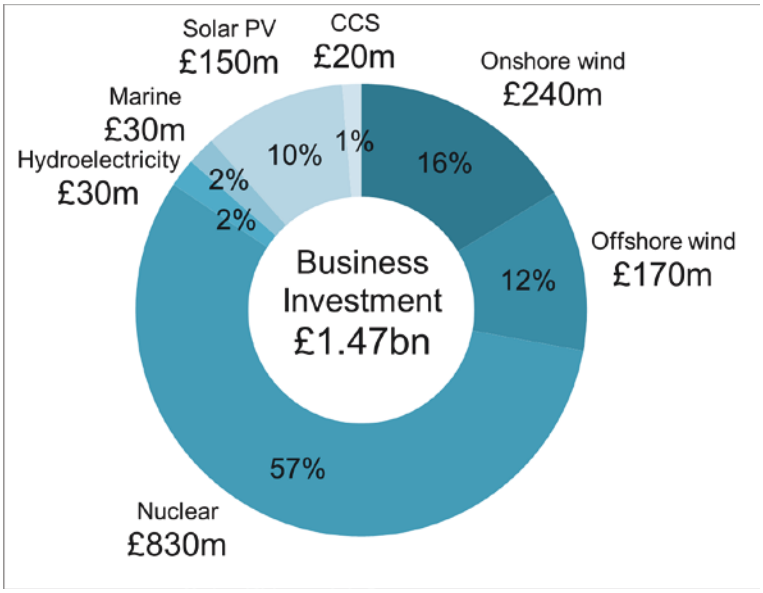
Table 9: Low carbon electricity – GVA (£m nominal) history, including supply chain

Sector	2010 (£m)	2011 (£m)	2012 (£m)	2013 (£m)	CAGR % ('10-'13)
Onshore wind	1,200	1,400	1,800	1,700	11.5%
Offshore wind	600	800	1,000	1,000	16.9%
Nuclear energy	3,300	3,500	3,800	3,500	2.8%
Hydroelectric energy	700	800	700	600	-2.1%
Marine	100	100	100	100	13.3%
Solar PV	2,700	2,100	2,300	3,300	6.3%
Carbon capture and storage	300	400	300	200	-7.3%
Low carbon electricity generation	**8,800**	**9,100**	**10,100**	**10,400**	**5.8%**

Source: TBR

- Both offshore and onshore wind showed compound growth of over 11.5% in GVA indicating the increase in the scale and importance of these sectors. The growth in offshore wind is particularly strong and reflects the large scale of new developments.
- Also as indicated previously, marine is characterised as still being in the development phase, with little turnover being generated from commercial activities. However, it appears that commercialisation is beginning to impact on performance. GVA has grown by a compound rate of 13.3% although the overall total is still modest. The limited size of the sector is commensurate with the level of business investment (£30m).
- Within the electricity generation group, the total investment by businesses of £1.47bn was distributed as follows: nuclear (£830m); onshore wind (£240m); offshore wind (£170m); solar PV (£150m); marine (£30m), hydroelectric (£30m) and CCS (£10m)[26].
- As noted above, the research estimates that private investment in CCS during 2013 was £10m. While government and EU funding in support of White Rose and Peterhead have been announced, final decisions on whether to go ahead will only be made in late 2015.

Figure 6: Business Investment in low carbon electricity, 2013



Source: TBR

- As indicated earlier, businesses noted that their capital spending was driven by a number of factors including: government policy; access to and level of subsidies; their level of confidence in the stability of the investment environment; the emergence of 'game changing' technologies; and changes to cost benefit ratios. Cost of capital and fossil fuel prices were seldom cited. Some smaller companies indicated that access to capital was a problem.
- The distribution of business investments by sector and asset type provide an indication of the point in the life cycle of the technologies and possibly the nature of the investors. Survey data shows that the majority of commitments in offshore wind and in solar PV were in capital equipment suggesting that developers consider the technology to be

[26] Business investment excludes purchases of land.

sufficiently stable enough to invest in offshore wind farms or PV installations. Conversely, for marine, business investment appears to be in the technology itself[27].

4.3 Spatial distribution

- The spatial analysis is based on the location of the individual business units. While this is considered to be the most effective way of analysing where employment is, it should be noted that some companies do not allocate jobs to local branches but to their head office. This can give rise to the perception of unevenness in job distribution.
- Furthermore, it is clear that not all jobs are co-located with the assets used to generate electricity. While most obvious for offshore wind, it is also relevant for onshore wind, where turbines tend to be located in rural, often upland locations. The operation of electricity generating plant tends to be highly automated, so requires few staff. In addition, much of the maintenance activity is technically complex so specialist teams tend to service a number of facilities and will therefore be based away from one or more sites.
- We also note that the type and location of employment varies over the asset lifecycle. In many cases civil engineering contractors are likely to set up site offices for large projects. This will result in large numbers of workers being located at the site during the construction phase. During the operations phase, the number of jobs falls dramatically and these may be dispersed from the site.
- In terms of geography, Scotland hosts significantly large elements of the low carbon electricity generation group. Onshore wind, hydropower, marine, and offshore wind are well above the 8% benchmark[28]. Solar PV is the standout sector for Wales, followed by nuclear. The importance of nuclear has fallen, which may be a reflection of Wylfa's position in the lifecycle; reactor 1 was retired in 2012 and reactor 2 is scheduled for close down at the end of 2015. A new ABWR[29] station is planned with site works to be commenced in 2018.
- Offshore wind is the lead sector for Northern Ireland.
- Nuclear and solar PV provide the largest amount of employment in England.
- Within England, the nuclear sector is concentrated in the North West. It contains nearly half of all the UK's employment. Other sectors concentrated in the region are hydropower, marine and solar PV. Offshore wind is strongly concentrated in London and the East of England. The London Array was, at the time of construction, the world's largest offshore wind farm[30].

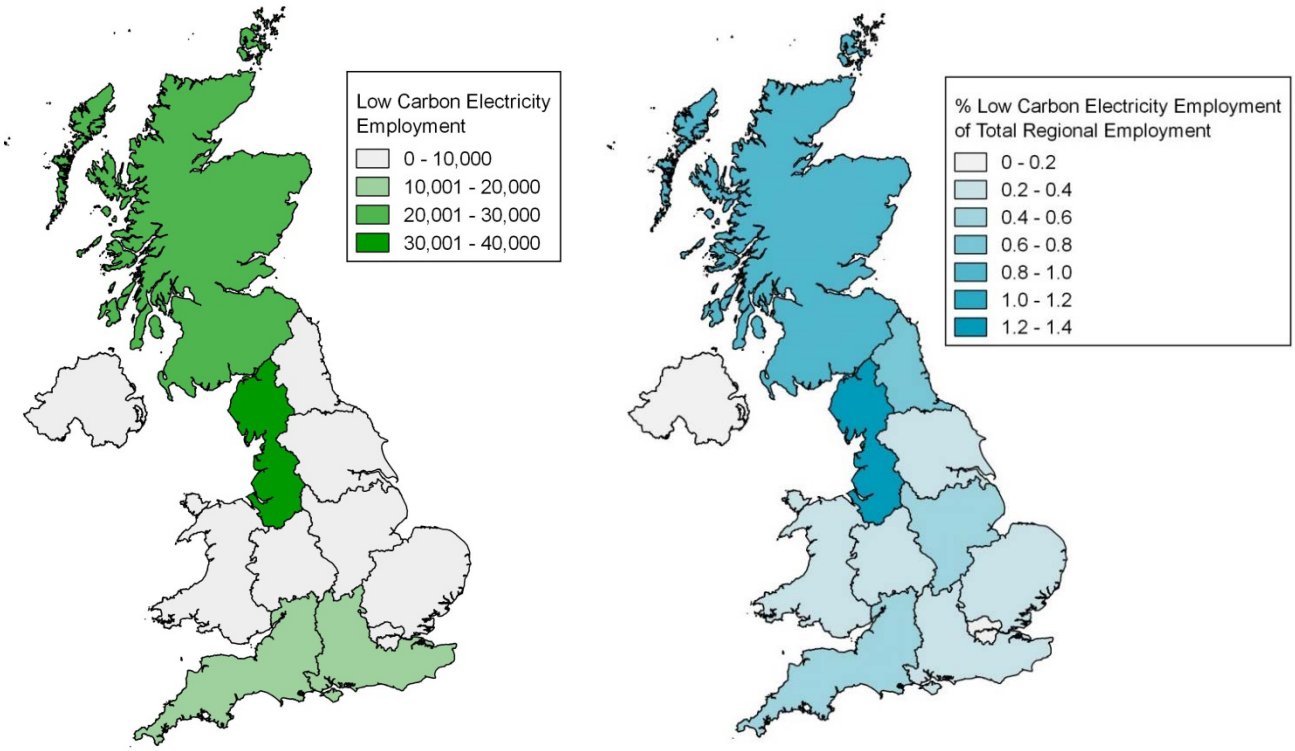
[27] The small numbers involved indicate that the data should be viewed with caution.
[28] Based on an approximate share of total UK employment.
[29] Advanced Boiling Water Reactor.
[30] www.londonarray.com

Table 10: Low carbon electricity – national distribution of employment, 2013

Sector	England	Wales	Scotland	Northern Ireland	Total
Onshore wind	12,800	600	5,400	300	19,000
Offshore wind	10,900	400	2,100	400	13,700
Nuclear energy	50,300	900	7,600	200	59,000
Hydroelectric energy	5,400	200	1,700	*	7,400
Marine	2,000	100	1,000	*	3,100
Solar PV	28,700	2,000	3,200	400	34,400
Carbon capture and storage	3,500	*	600	*	4,100
Low carbon electricity	113,600	4,200	21,500	1,400	140,800

Source: TBR
Note. * indicates data is suppressed to prevent identification of individual businesses

Figure 7: Regional and national distribution of employment in low carbon electricity, 2013



Source: TBR

5 Low carbon heat

This section presents key findings from the analysis of the size and performance of the low carbon heat sector grouping. The low carbon heat group comprises those sectors primarily involved in the capture and distribution of heat energy. The sectors included in this grouping are:

- Geothermal heat – primarily deep geothermal but includes some ground source heat[31]
- Heat pumps – including: ground, air and water source heat
- Solar thermal
- Heat networks - incorporates the distribution of heat, but not its generation. This will either be covered by energy generation from waste, biomass and deep geothermal or excluded if it is generated from fossil fuels.

The scope of the work precluded the ability to disaggregate CHP facilities from those solely generating electricity, or heat, or to identify where waste heat has been captured for heating purposes. The design, manufacture, installation and operation of biomass plants is included in the energy generation from waste and biomass group along with facilities fuelled by waste and gas from landfill, rather than here in low carbon heat, despite their widespread use as a heat source[32].

The full set of analysis can be located in Appendix I - Full data tables.

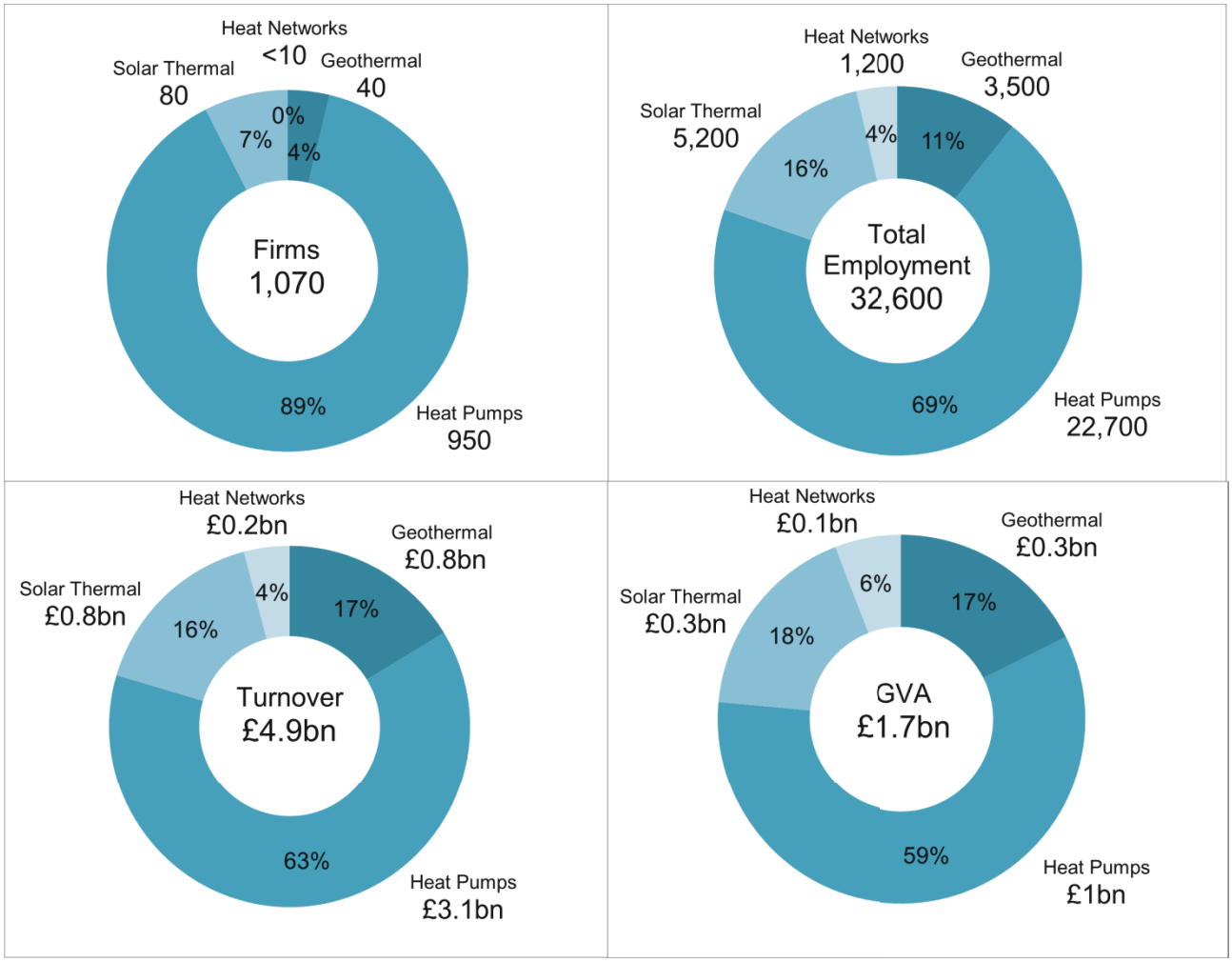
5.1 Size and scale

- Low carbon heat is one of the relatively small groupings with 9% of firms, 7% of employment, 4% of turnover and 4% of GVA. It is represented by 1,070 firms and contributes 32,600 employees when the supply chain is also taken into account.
- Turnover generated by low carbon heat was £4.9bn in 2013 and this delivered a GVA output of £1.7bn.
- Heat pumps dominate the group across all four key metrics of firms, employment, turnover and GVA. While this is most prominent in firm numbers, the relatively small size of businesses means that the proportion of employment, turnover and GVA is somewhat less. Solar thermal and geothermal (including some heat pump activity) are evenly matched, though solar thermal firms tend to be smaller. Heat networks is, by far, the smallest sector in terms of firms. However businesses are relatively large, so take a larger share of employment, turnover and GVA.
- As indicated above, the boundary between ground source heat pumps and geothermal energy can be somewhat indistinct. While formal definitions of geothermal energy tend

[31] As noted in the text below, the term geothermal formally refers to tapping into natural geysers or heat sources in excess of 200 metres deep, however the industry takes a less definitive approach and often describes ground source heat pumps as geothermal. It was beyond the scope of this study to determine whether activities undertaken by individual businesses were truly geothermal or merely ground source.
[32] The rationale for this is that the largest standalone (and therefore identifiable) biomass, waste and landfill gas facilities are used to generate electricity rather than biomass, e.g. Drax. The recently commissioned (2015) CHP facility at Tullis Russell is primarily intended to serve the paper mill rather than generate revenues as a power generator.

to include only natural geysers or tapping into heat sources in excess of 100-200 metres deep, in practice the industry tends to less precise and can often use the term 'geothermal' to refer to all sub-surface energy sources[33]. While we have sought to keep the two separate by adopting a formal approach, businesses will have been allocated to sectors based on how they describe their activities. The impact of this is that the geothermal sector may have been overstated at the expense of the ground source element of heat pumps.

Figure 8: Firms, Employment, Turnover and GVA in low carbon heat and its supply chain, 2013



Source: TBR

- The high capital costs associated with accessing deep geothermal energy sources means that they are seldom viable unless the heat can be utilised fully, e.g. in a large building with large heating needs, such as a hospital, or by powering a heat network. The latter provides another example of two low carbon sectors coming together

[33] As noted above geothermal heat and ground source heat pumps are often conflated by the industry. True geothermal energy seeks to access high temperature sources created by the earth's core. Such sources are generally found on the edge of tectonic plates and result in temperatures up to 370˚ and require significant drilling to access them.

resulting in boundaries becoming blurred, in this case between geothermal heat and heat networks. Thus some care should be exercised when considering the relative size of the sectors.

- The interviews with firms provided a number of useful insights. Heat pumps and geothermal have the highest penetration of non-domestic users. For example, the market for reverse-cycle heating facilities in commercial and large offices is well established and had operated effectively prior to the introduction of the RHI[34]. The RHI for domestic buildings only came into force in April 2014 so the effects are not yet reflected in the data.
- Both the survey work and interviews highlighted the close interaction between the low carbon energy technologies used in domestic dwellings. We found that the majority of firms involved in installation were active across several sectors, for example heat pumps, solar thermal, solar PV, biomass equipment and even, in some cases, small scale onshore wind. This appears to be the result of several factors: many of the technologies are mutually compatible, e.g. solar PV, solar thermal and biomass equipment; the domestic market is relatively homogenous and can be penetrated with multi-product marketing; government promotion of renewable and low carbon energies to households, the supply of standard equipment designed for use in the home and the skills required being relatively widely available[35].
- The boundary between solar thermal and solar PV is likely to become more diffuse with the development of hybrid systems, which deliver both heat (hot water) and electricity.
- Many of the technologies used in the domestic market are conducive to retro-fitting, e.g. solar PV and insulation. However the capital cost and nature of heat networks mean that they are primarily employed in either new build estates are where the heat source and point of use can be connected relatively easily and with minimal heat loss.

5.2 Performance

- All sectors have shown growth across the three key metrics[36] over the period 2010 – 2013.

Table 11: Low carbon heat – employment history, including supply chain

Sector	2010	2011	2012	2013	CAGR % ('10-'13)
Geothermal	2,700	2,900	3,200	3,500	8.5%
Heat pumps	20,900	21,200	21,900	22,700	2.9%
Solar thermal	4,600	4,800	5,100	5,200	4.0%
Heat networks	1,000	1,100	1,100	1,200	3.8%
Low carbon heat	29,300	30,100	31,300	32,600	3.6%

Source: TBR

- The absolute growth in employment, along with the rate of change in turnover and GVA exceeding inflation, indicate that all sectors are growing in real terms. Analysis of the

[34] Renewable Heat Incentive.
[35] Primarily electricians and plumbers.
[36] Employment, turnover and GVA.

year on year data indicates that 2010-2011 was a more muted period with patchy performance across turnover and GVA. Improvement since 2011 has been steady.

Table 12: Low carbon heat – turnover (£m nominal) history, including supply chain

Sector	2010 (£m)	2011 (£m)	2012 (£m)	2013 (£m)	CAGR % ('10-'13)
Geothermal	600	500	600	800	12.0%
Heat pumps	2,700	2,700	2,800	3,100	4.5%
Solar thermal	700	800	800	800	3.4%
Heat networks	100	100	100	200	6.4%
Low carbon heat	4,200	4,100	4,400	4,900	5.4%

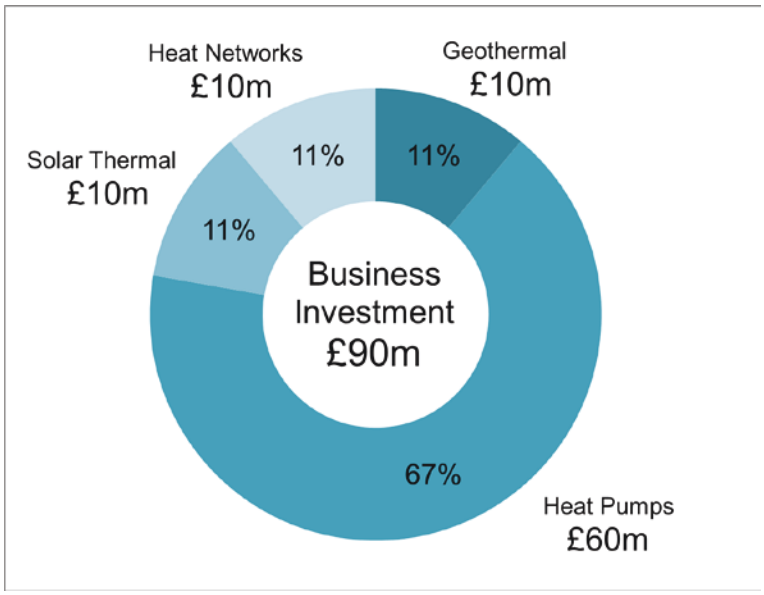
Source: TBR

Table 13: Low carbon heat – GVA (£m nominal) history, including supply chain

Sector	2010 (£m)	2011 (£m)	2012 (£m)	2013 (£m)	CAGR % ('10-'13)
Geothermal	200	200	300	300	11.0%
Heat pumps	1,000	900	1,000	1,000	1.5%
Solar thermal	200	300	300	300	3.6%
Heat networks	100	100	100	100	6.9%
Low carbon heat	1,500	1,500	1,600	1,700	3.7%

Source: TBR

Figure 9: Business Investment in low carbon heat, 2013



Source: TBR

- Firms in low carbon heat have invested £90m in their businesses in 2013. This represents 1.8% of turnover.

- Heat pumps are also the largest business investor at 67%, whilst the other three sectors have invested similar levels (all £10m which represents 11% of total investment for the sector grouping).
- Across the low carbon heat group, the majority of business investments were in capital equipment such as plant, machinery and IT, though there were a number of R&D projects involving new products and technologies.

5.3 Spatial distribution

- Scotland has higher levels of employment in most of the low carbon heat sectors than the proportion of population would suggest. Only heat networks are (marginally) below the 8% benchmark[37]. Analysis of the data indicates that the performance appears to be driven by the presence of manufacturing facilities as well as the proportionally larger market for heating equipment.
- In Wales, there is a concentration of solar thermal activity even though heat pumps are the largest employer in absolute terms.
- A similar pattern exists in Northern Ireland as in Wales. However, for both nations, the low carbon heat sector is relatively small in comparison to population.
- In England, heat pumps are by far the largest employer, followed at distance by solar thermal and geothermal. Within the English regions, the North East has a specific strength in geothermal.

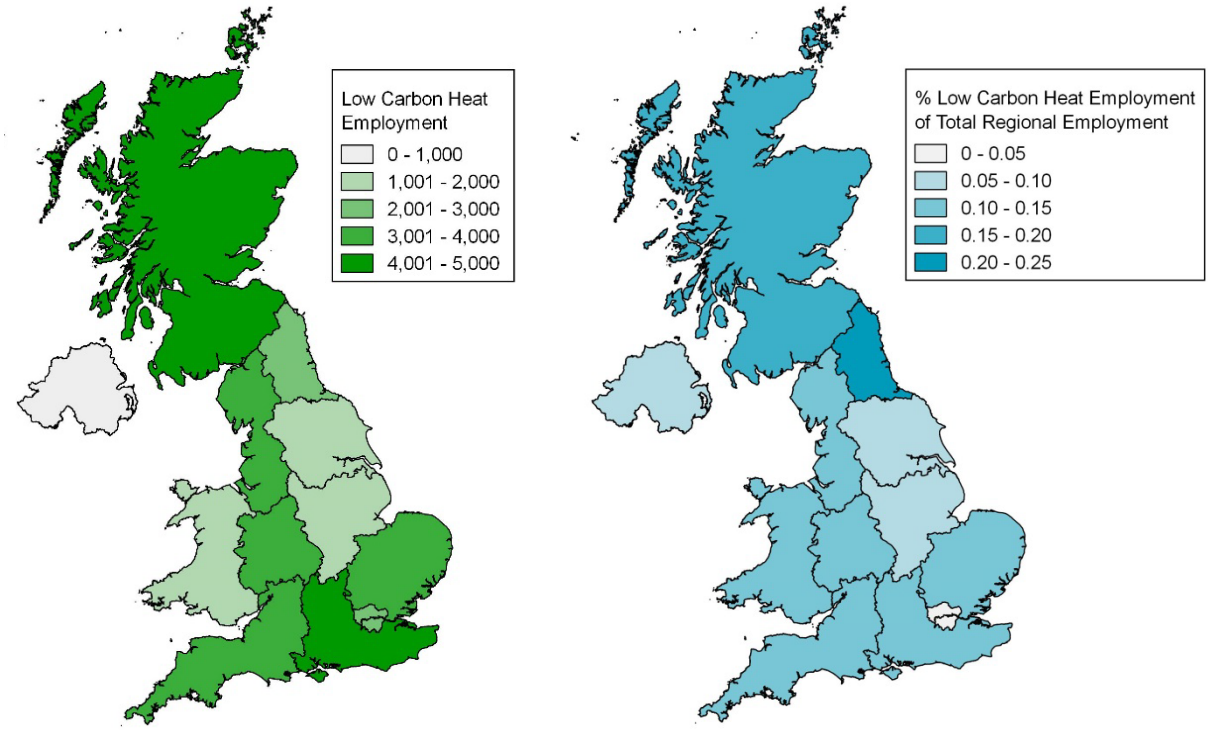
Table 14: Low carbon heat – national distribution of employment, 2013, including supply chain

Sector	England	Wales	Scotland	Northern Ireland	Total
Geothermal	2,700	100	600	*	3,500
Heat pumps	18,300	900	3,100	400	22,700
Solar thermal	3,800	200	1,100	100	5,200
Heat networks	900	*	100	*	1,200
Low carbon heat	25,800	1,300	5,000	500	32,600

Source: TBR[38]
Note. * indicates data is suppressed to prevent identification of individual businesses

[37] 8% of UK population resides in Scotland
[38] Asterisks are used here and throughout this report to prevent disclosure.

Figure 10: Regional and national distribution of employment in low carbon heat, 2013



Source: TBR

6 Waste processing, energy from waste and biomass

This section presents key findings from the analysis of the size and performance of the Waste processing, energy from waste and biomass sector grouping. The Waste processing, energy from waste and biomass grouping brings together the four sectors primarily involved in extracting value and energy (electricity, heat, or both) from products normally considered as waste or biomass. These are:

- Recycling – recovery and reprocessing materials from waste or alternative fuels.
- Generation of energy from waste and biomass – usually through combustion. This includes the use of biomass, refuse, landfill gas and other wastes as fuels[39], as well as the generation of electricity and heat from anaerobic digestion[40]. It also includes the design, manufacture and installation of the equipment used to generate electricity and heat.
- Alternative fuels – primarily from landfill gas, processing forestry, agricultural and food waste, though it does include growing of crops especially for conversion into fuel.
- Biomass equipment – their design, manufacture and installation. Note, this includes biomass boilers designed for the generation of electricity, the production of heat or both (often referred to as combined heat and power or CHP).

Note elements of anaerobic digestion (AD) and landfill gas are included in this group. The supply and operation of AD equipment is primarily contained within alternative fuels, due to the principal output being methane gas. However, where gas is used directly to generate heat or electricity by burning, it is incorporated into the generation of energy from waste and biomass.

The report does not seek to disaggregate the use of biomass boilers to generate power, heat or CHP. The principal reason for this was the degree of complexity that would be added to the survey work if all sectors were to be analysed at a further level of detail.

The use of waste and biomass to generate electricity, heat or both, primarily for internal use, e.g. within a factory, school or hospital is not included in the report on the basis that it would have proven almost impossible to identify all such instances.

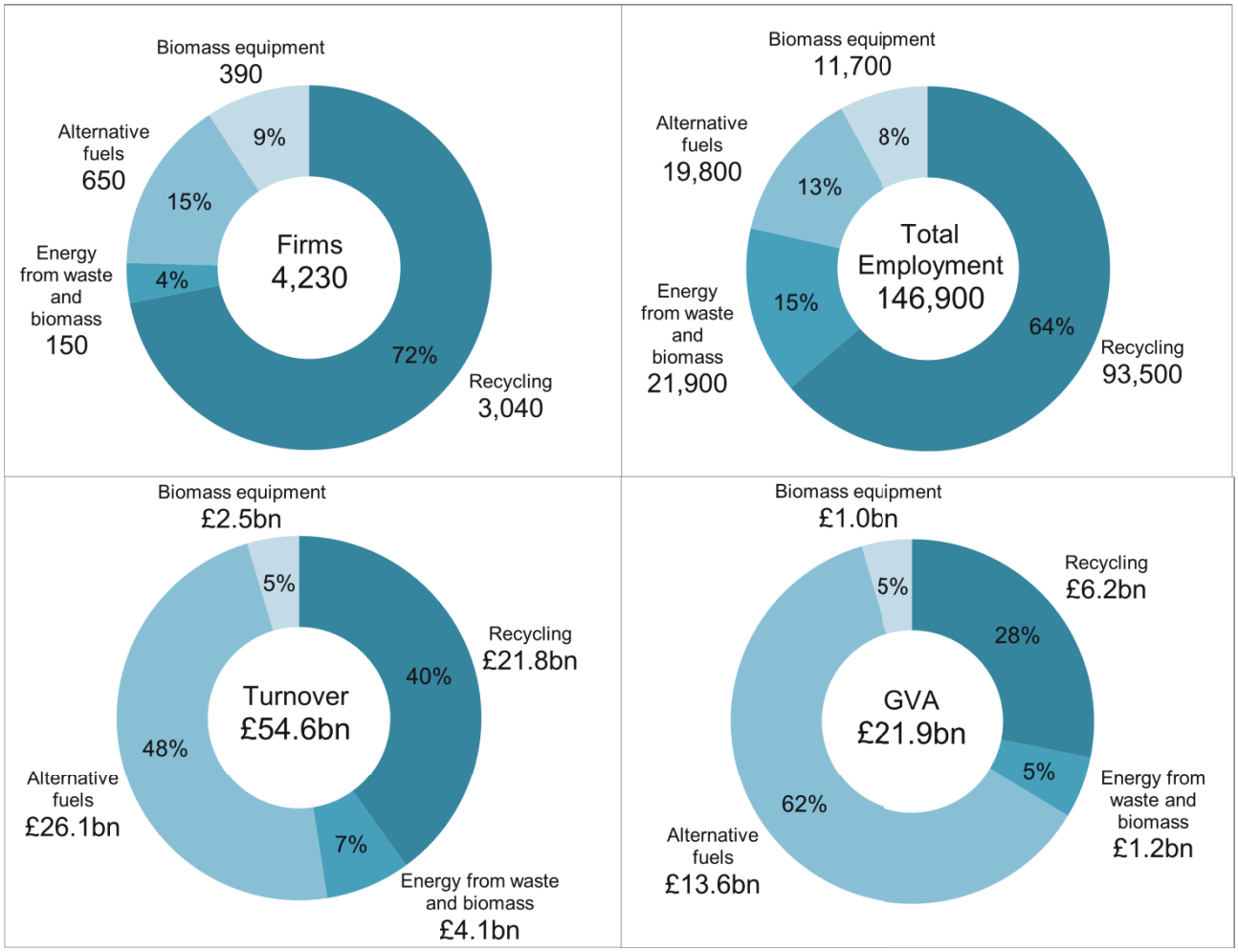
The full set of analysis can be located in the Appendix I - Full data tables.

[39] Thus the Cory Environmental Riverside Resource Recovery facility at Belvedere is included here along with the Veolia Energy-Dalkia plant at Chilton. However, internal self-supply facilities are excluded. This means that the overall value of this sector is under reported.
[40] This only includes those facilities where the AD plant feeds directly into a boiler used to generate heat and/or electricity.

6.1 Size and scale

- This is the largest group with 37% of firms, 32% of employment, 45% of turnover and 49% of GVA.
- It is populated by 4,230 firms operating in direct activities. Total employment in the sector is 146,900 and these firms generate aggregate turnover of £54.6bn and GVA of £21.9bn.
- The group is dominated by recycling and recovery, which has nearly three quarters of the firms, 64% of employment, 40% of turnover and 28% of GVA. These findings suggest that this sector is labour intensive. The average size of businesses is relatively small at around 15.5 employees per firm. However, a significant proportion of these firms are made up from local branches of the major refuse collectors and re-processors. However, around one third of their employment is in the non-low carbon economy, e.g. landfill, which is excluded from the analysis. The relatively low levels of turnover and GVA relate to the value of the goods that they are dealing with.
- The importance of the production and use of alternative fuels is seen in the data, with businesses in alternative fuels comprising 15% of the firms and 13% of employment but 48% of turnover and 62% of GVA.
- Biomass equipment and generation of energy from waste and biomass are similar in terms of their impact on the sector. There are more businesses involved in biomass equipment (9%) than energy from waste and biomass (4%). However, their small size and emphasis on supply and installation means that they employ fewer staff (8% compared to 15%), generate less turnover (5% against 7%) and a similar level of GVA (both 5%).

Figure 11: Firms, Employment, Turnover and GVA in waste processing, energy from waste and biomass and its supply chain, 2013



Source: TBR

6.2 Performance

- All sectors increased employment over the period 2010 – 2013. The compound annual growth rate for employment was 3.3%.
- Alternative fuels grew most significantly over the three year period, with a compound rate of 5.0%.
- The sector group appears to have weathered the recession with some of the sectors experiencing flat spots in employment during limited periods in the years under review. Growth appears to have picked up in recent years for all but biomass equipment, which has remained relatively flat between 2011 and 2013.
- Energy generation from waste and biomass operations tend to be capital intensive and span the range from small semi-commercial operations to large power stations, e.g. Chilton and Belvedere, as well as EPRL's plant in Ely that consumes straw. It includes the generation of electricity and operation of CHP facilities on a commercial basis[41].

[41] The operation of biomass boilers is only included where these represent a significant and quantifiable part of a businesses' operation. It does not cover internal process use, where generation of heat and power from

- In the UK we are also extracting value through energy recovery. In 2013 it is estimated[42] that £447.4m of electricity (9,005 GWh) was generated from waste[43]. Of this, £155.5m (3,130 GWh[44]) was generated through residual waste treatment[45], £35.1m (707 GWh) was generated through Anaerobic Digestion (AD)[46], and £256.8m (5,169 GWh) was generated through the capture of landfill gas.
- It should also be noted that these fuel sources may also be used to generate heat, e.g. in CHP plants. However, it was beyond the scope of this study to disaggregate the generation of heat and electricity from, for example, CHP facilities.
- The interviews indicated that access to consistent high quality waste and biomass streams was becoming an issue for many businesses; there were often limitations on the inputs that their existing technologies could handle, and the quality of output was impacted by the nature of the raw materials, e.g. calorific value and moisture content. However, some firms noted that they had achieved competitive advantage from investing in plant capable of processing more varied and lower quality inputs.
- Many of the materials generated by the re-processors, e.g. paper and glass are traded commodities so subject to market prices. This can have significant impacts on performance on a year on year basis.

Table 15: Waste processing, energy from waste and biomass – employment history, including supply chain

Sector	2010	2011	2012	2013	CAGR % ('10-'13)
Recycling - recovery and reprocessing of materials from waste	85,200	86,200	89,600	93,500	3.2%
Energy generation from waste and biomass	20,100	20,100	20,600	21,900	2.8%
Alternative fuels	17,100	17,800	18,700	19,800	5.0%
Biomass equipment	10,900	11,700	11,700	11,700	2.2%
Waste processing, energy from waste and biomass	133,400	135,800	140,600	146,900	3.3%

Source: TBR

- Turnover performance has also been positive across the study period. The compound growth rate is 11.9% per annum with Alternative fuels again the stand out sector (21.9% per annum). All sectors suffered a decline in turnover between 2010 and 2011 but all have also recovered during the period 2011 to 2013.

biomass or other alternative fuels is used to displace traditional fossil fuels or where heat is sold as a by-product to one or more neighbouring businesses.

[42] See: Resource management: a catalyst for growth and productivity, published by Defra, Feb 2015

[43] Calculated using GWh output data from the DECC Digest of the UK Energy Statistics 2014 and an average wholesale energy price of £49.68 per megawatt hour (APX power spot exchange).

[44] Based on an 85% load factor

[45] This includes sewage sludge, biodegradable waste and animal biomass.

[46] Note – some of the energy generated through AD will be from farm waste.

Table 16: Waste processing, energy from waste and biomass – turnover (£m nominal) history, including supply chain

Sector	2010 (£m)	2011 (£m)	2012 (£m)	2013 (£m)	CAGR % ('10-'13)
Recycling - recovery and reprocessing of materials from waste	18,700	15,900	19,000	21,800	5.3%
Energy generation from waste and biomass	3,800	3,500	4,000	4,100	3.2%
Alternative fuels	14,400	13,600	18,500	26,100	21.9%
Biomass equipment	2,100	2,000	2,200	2,500	6.5%
Waste processing, energy from waste and biomass	39,000	35,000	43,700	54,600	11.9%

Source: TBR

- The pattern for GVA broadly follows that for turnover, with a fall in 2010 – 2011 and rapid rises in the following periods. However, the output performance of energy from waste an biomass is notable in that GVA has declined in the period 2012 to 2013 and this has driven an overall negative compound annual rate (-1.2%).

Table 17: Waste processing, energy from waste and biomass – GVA (£m nominal) history, including supply chain

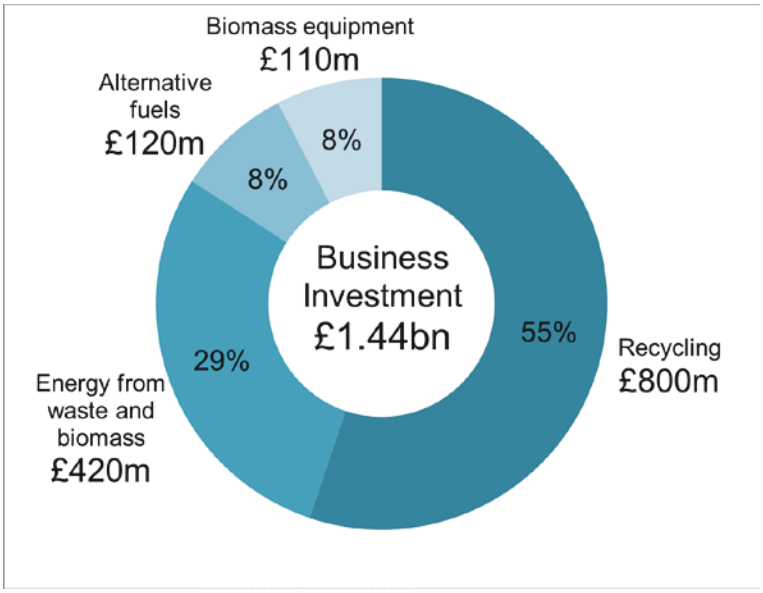
Sector	2010 (£m)	2011 (£m)	2012 (£m)	2013 (£m)	CAGR % ('10-'13)
Recycling - recovery and reprocessing of materials from waste	5,500	4,700	5,600	6,200	4.0%
Energy generation from waste and biomass	1,200	1,200	1,500	1,200	-1.2%
Alternative fuels	7,000	6,600	9,300	13,600	24.4%
Biomass equipment	800	900	900	1,000	8.1%
Waste processing, energy from waste and biomass	14,500	13,300	17,300	21,900	14.7%

Source: TBR

- Businesses within the group are estimated to have invested £1.44bn in 2013. In order of magnitude, they are: recycling and re-processing of materials (£800m); energy generation from waste and biomass (£420m); alternative fuels (£120m), and; biomass equipment (£110m).
- In terms of the types of business investment, projects involving spending on: capital equipment such as plant and machinery; and R&D and the development and protection of IP were the most prevalent according to the survey data. Companies primarily involved in recycling and biomass boilers provided the largest number of business investment projects. There were relatively few projects undertaken by companies based in the alternative fuels and energy from waste and biomass sectors. However, a small number of very large capital projects may have influenced the overall results. Furthermore, the large capital nature of some of the sectors would also mean that business investment is lumpy over time, so caution is urged when considering the data for a single year.
- Some interviewees noted that security of supply of biomass fuel was becoming a challenge; in terms of market prices and the tightening up of qualifying criteria for RHI

subsidies. As a consequence, lenders appeared to be unwilling to lend unless fuel supplies could be guaranteed. This has led numerous business investments to be put on hold.

Figure 12: Business Investment in waste processing, energy from waste and biomass, 2013



Source: TBR

6.3 Spatial distribution

- Overall, England (89%) appears to have a greater share of activity in the group than population data would suggest[47].
- Within the devolved administrations, Scotland has a clear strength in alternative fuels, with over 14% of the UK's employment. This is largely a function of the concentration in agriculture and forestry. Allied to this are specialist plants for converting wastes into fuels using industrial-scale processes.
- In other sectors, the devolved administrations have levels of activity at or below their proportions of the population.
- Within the English regions; the West Midlands has the highest concentration of employment in biomass boilers, the South East leads on all other sectors. Head offices and the concentration of population are seen as the key factors behind this[48].

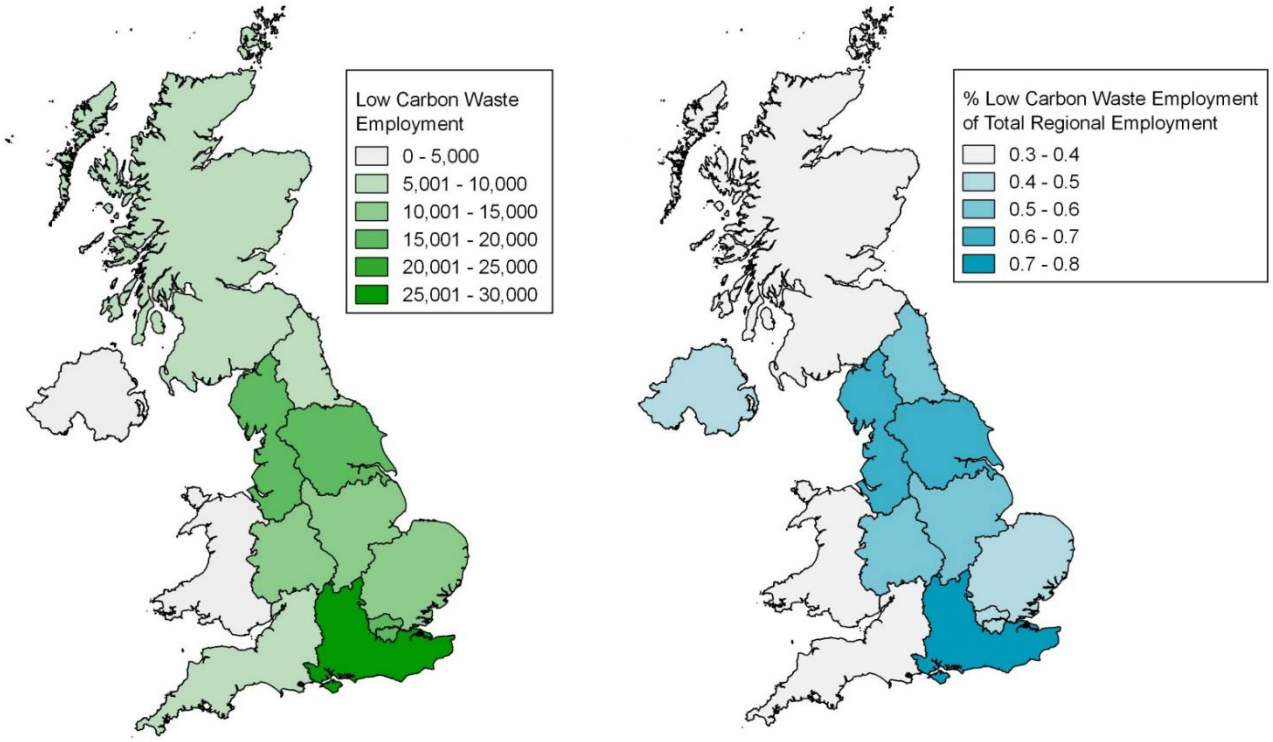
[47] England has 84% of the UK's population.
[48] Where employment cannot be attributed accurately to local branches it has been allocated to head offices.

Table 18: Waste processing, energy from waste and biomass – national distribution of employment, 2013, including supply chain

Sector	England	Wales	Scotland	Northern Ireland	Total
Recycling - recovery and reprocessing of materials from waste	84,200	2,700	4,000	2,700	93,500
Energy generation from waste and biomass	20,400	300	900	300	21,900
Alternative fuels	16,200	600	2,800	200	19,800
Biomass equipment	9,800	400	1,100	500	11,700
Waste processing, energy from waste and biomass	**130,600**	**4,000**	**8,700**	**3,600**	**146,900**

Source: TBR

Figure 13: Regional and national distribution of employment in waste processing, energy from waste and biomass, 2013



Source: TBR

7 Energy efficiency products

This section presents key findings from the analysis of the size and performance of the Energy efficiency products sector grouping. The energy efficiency products grouping covers a range of product types aimed at optimising the use of energy by consumers and businesses. The grouping comprises:

- Energy efficient lighting – design, manufacture and distribution of LED and CF lamps and luminaires[49].
- Insulation – manufacture and specialist (retro-fit) installation.
- Energy-efficient windows and doors – manufacture and supply only.
- Heat recovery and ventilation systems - manufacture and supply only, except for specialist industrial process applications.
- Energy controls and control systems – design and supply only. This includes smart meters, displays, communications hubs and controls.
- Sustainable architecture and buildings – includes the supply of reprocessed building materials and other specialist low carbon materials.

The full set of analysis can be located in the Appendix I - Full data tables.

It should be noted that the requirement to include only those products which could demonstrate a step change in performance has limited the scope of products and technologies included in the analysis. The implication is that this may underestimate the size of the group where demand includes upgrading of equipment to more efficient models, e.g. condensing boilers are excluded, which can deliver significant reductions in energy consumption. Similar arguments are used for excluding white goods which are constantly being upgraded in terms of energy use, though their underlying technology remains the same.

The supply of energy efficiency equipment to industrial settings (and the use within these sectors) has also been excluded. Therefore the true size of the energy efficiency sector is likely to be significantly larger if all aspects of improving energy efficiency were included.

7.1 Size and scale

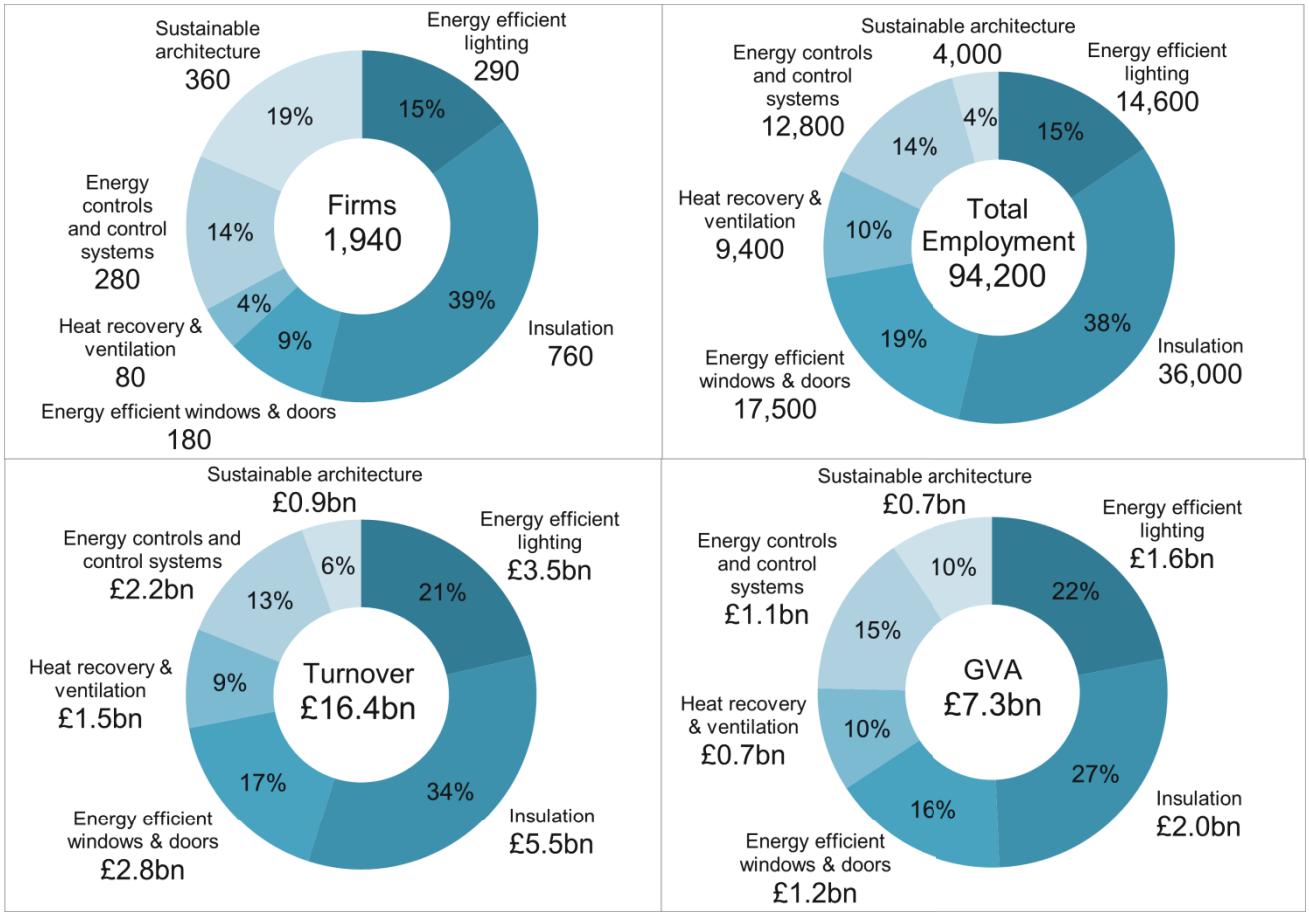
- Energy efficiency products represents a mid-sized group in terms of firm numbers. With 17% of the population, it has fewer businesses than waste processing, energy from waste and biomass and low carbon electricity, but more than low carbon heat, low carbon services and other low carbon sectors.
- It is populated by 1,940 firms in direct activities. Total employment in the sector is 94,200 and these firms generate aggregate turnover of £16.4bn and GVA of £7.3bn.
- Insulation stands out as the major sector within the group with 39% of the firms, followed by sustainable architecture, lighting and energy controls and control systems.
- Relative firm size has an impact on employment contribution: insulation; energy efficient lighting; and controls are average sized and employ workers in roughly the same

[49] LED – light emitting diode and CF – compact fluorescent are both types of low energy lighting.

proportion as firm numbers. For example, insulation represents 29% of firms and 38% of employment. However, as heat recovery and ventilation and energy efficient windows and doors companies tend to be relatively large, they provide proportionally more employment (4% of firms and 10% of employment and 9% of firms and 19% of employment respectively), whereas sustainable architecture firms are relatively small (19% of firms and 5% of employment). The latter is a function of architects' practices being, in the main, small and the proportion of employment included for the processing and supply of building materials also being limited.

- Insulation also generates the highest turnover of all sectors in the group, followed by energy efficient lighting and windows and doors. While there is no clear evidence why lighting should generate more turnover than windows and doors, there are two possible reasons. First, many low energy lighting units are still earning premium prices (especially LEDs) and are seeing high levels of replacement demand and, second the distribution chain for lighting tends to be via distributors (which is included in the definition), whereas this tends not to be the case for windows and doors. It is anticipated that as the longer life of LED and CF bulbs work through and saturation is achieved, that replacement demand will diminish (see below).

Figure 14: Firms, Employment, Turnover and GVA in energy efficiency products and its supply chain, 2013



Source: TBR

- The interviews with businesses, however, highlighted that much of the demand for low energy lighting comes from replacements, rather than solely installation in new build.

Once this market becomes saturated, it is anticipated that the much longer lifespan of LEDs and CFLs could lead to a reduction in turnover.

- The differences in GVA between the energy efficiency sectors is more muted. With 27% of all GVA, insulation generates less than three times that of sustainable architecture and buildings (10%), despite having over six times the turnover. This is likely to reflect the higher intensity of labour in the insulation sector, especially retrofit installation.
- There are differences within the group in terms of policy support. The Green Deal helps householders make energy-saving improvements to their homes. These cover areas such as: insulation; heating; draught-proofing; double glazing and renewable energy generation. Grants and support are available such as through the Energy Companies Obligation[50] and Green Deal Home Improvement Fund[51] for the retrofitting of loft, cavity, and wall insulation, double glazing, and a number of other measures. Demand for energy efficient lighting, windows and doors and insulation is, to a significant degree, also underpinned by the minimum standards within the Building Regulations, together with the Ecodesign and Energy Labelling directives. However, businesses, when interviewed, did indicate that these minimum standards (for insulation) became effective maxima in practice, as builders and contractors found clients unwilling to pay extra for additional improvements in performance.
- The various sectors in the group were included in the definition of low carbon products on the basis that when used together they could deliver step-change improvements to the performance of buildings.

7.2 Performance

- Performance across the group has been mixed. Some sectors such as insulation and windows and doors have shown growth in employment, whereas others like energy controls and heat recovery have contracted. Overall, the group gained just over 1,800 headcount or 2.3% at a compound annual rate of 0.8%.
- A review of the year on year changes indicate that performance has been very mixed over the period, unlike in the other groups where 2010 – 2011 was particularly difficult but more recent years have generally been positive.

[50] https://www.gov.uk/government/policies/helping-households-to-cut-their-energy-bills/supporting-pages/energy-companies-obligation-eco

[51] https://www.gov.uk/green-deal-energy-saving-measures/get-money-back-from-the-green-deal-home-improvement-fund

Table 19: Energy efficiency products – employment history, including supply chain

Sector	2010	2011	2012	2013	CAGR % ('10-'13)
Energy-efficient lighting	14,300	14,300	14,500	14,600	0.6%
Insulation	32,700	33,600	34,400	36,000	3.2%
Energy-efficient windows and doors	16,800	16,400	17,000	17,500	1.3%
Heat recovery and ventilation	9,500	9,500	9,500	9,400	-0.4%
Energy controls and control systems	14,900	15,400	14,100	12,800	-4.9%
Sustainable architecture and buildings	3,900	4,200	4,300	4,000	0.6%
Energy efficiency products	**92,100**	**93,300**	**93,800**	**94,200**	**0.6%**

Source: TBR

- Energy control systems and sustainable architecture and buildings increased employment in 2010 – 2011 but reduced employment in 2012 – 2013.
- As indicated above, the majority of the products and services featured within the group relate to the construction and use of buildings. Furthermore, demand for energy efficiency products arises from both new build and refurbishments or improvements. The number of dwellings completed in the UK hit a low of 138,000 in 2010, some 22% below the figure for 2000. In 2011 they rose to 142,000, 144,000 in 2012, but fell back to 138,000 in 2013[52]. Thus demand from new build housing has been muted and a likely contributor to the limited change in employment figures.
- The figures for turnover are similarly flat overall, with positive changes being reported by the insulation, energy controls and sustainable architecture and buildings sectors, but falls by all the others. Overall, the group registered a compound growth of 0.9% per annum.
- The year on year turnover numbers provide no discernible patterns though the sector overall suffered a decline between 2010 and 2011 and recovered somewhat between 2011 and 2013.

Table 20: Energy efficiency products – turnover (£m nominal) history, including supply chain

Sector	2010 (£m)	2011 (£m)	2012 (£m)	2013 (£m)	CAGR % ('10-'13)
Energy-efficient lighting	3,800	3,300	3,100	3,500	-2.5%
Insulation	4,800	4,700	5,100	5,500	4.7%
Energy-efficient windows and doors	3,100	2,700	2,800	2,800	-3.5%
Heat recovery and ventilation	1,500	1,400	1,500	1,500	-0.4%
Energy controls and control systems	1,900	1,900	2,100	2,200	5.1%
Sustainable architecture and buildings	900	900	900	900	0.8%
Energy efficiency products	**15,900**	**15,000**	**15,500**	**16,400**	**0.9%**

Source: TBR

[52] DCLG, Permanent dwellings completed, United Kingdom, November 2014.

- The GVA data may be more insightful in that it shows either flat performance or decline for 2010 – 2011, followed by significant improvements in the subsequent two years. On the face of it, the data suggest that businesses faced a difficult time during the recession and took active steps to improve productivity. The positive results start to appear in the 2013 GVA data.

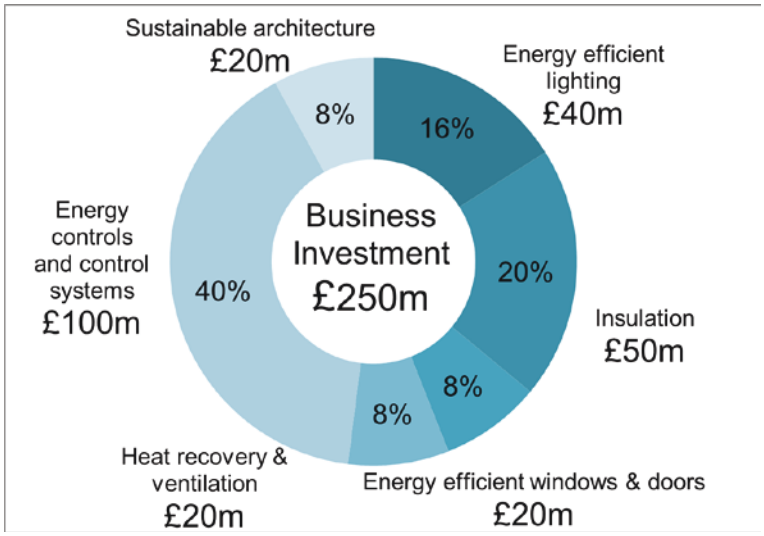
Table 21: Energy efficiency products – GVA (£m nominal) history, including supply chain

Sector	2010 (£m)	2011 (£m)	2012 (£m)	2013 (£m)	CAGR % ('10-'13)
Energy-efficient lighting	1,700	1,300	1,200	1,600	-0.9%
Insulation	1,800	1,800	1,800	2,000	3.9%
Energy-efficient windows and doors	1,500	1,100	1,200	1,200	-5.5%
Heat recovery and ventilation	700	600	600	700	2.1%
Energy controls and control systems	800	800	900	1,100	10.6%
Sustainable architecture and buildings	600	500	500	700	2.7%
Energy efficiency products	**7,000**	**5,900**	**6,200**	**7,300**	**1.5%**

Source: TBR

- The research estimates total investment for the group in 2013 at £250m. Energy controls is the sector which is investing most significantly in absolute terms (£100m) with insulation (£50m) being the next most significant. When considering the number and type of business investment projects, the survey respondents indicated that capital equipment and other, non-specified activities, were most prevalent. Further investigation indicates that training and the purchase of software were frequently mentioned.
- Businesses in energy controls undertook the largest number of business investment projects. These were primarily split between R&D and IP development and new capital equipment.

Figure 15: Business Investment in energy efficiency products, 2013



Source: TBR

7.3 Spatial distribution

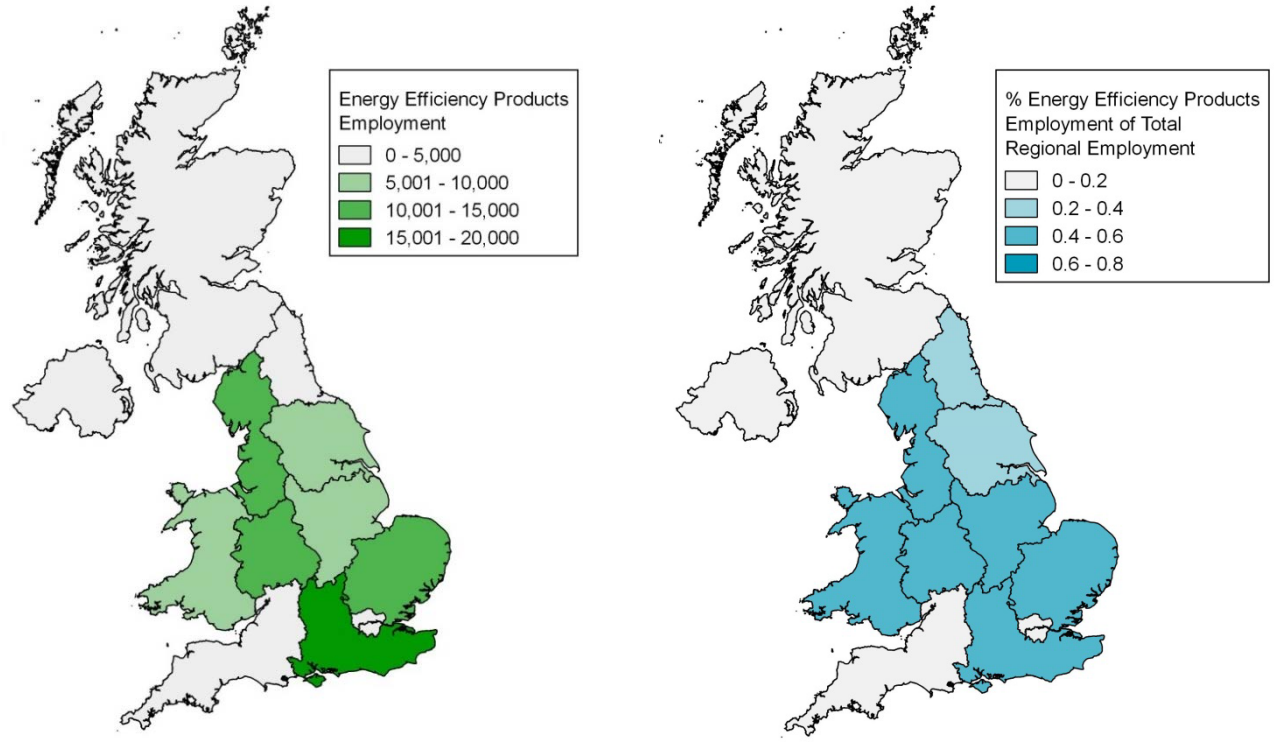
- England and Wales appear to have a share of the group's employment that is marginally greater than or in line with their share of the UK population. Scotland and Northern Ireland have slightly less than their expected shares.
- In all cases, insulation provides the largest absolute contribution to employment.
- Within the devolved administrations, Wales has a significant strength in energy-efficient windows and doors, whereas England has a noticeable peak in energy controls.
- Within England, the South East has the greatest share in employment in all sectors except insulation and energy efficient doors and windows. For insulation, employment is concentrated in the North West and East Midlands, whereas, the West Midlands and North West have the greatest concentrations of employment in energy efficiency products. The size of the insulation sector, in comparison to the others, means that overall, the greatest employment is in the North West.

Table 22: Energy efficiency products – regional distribution of employment (2013), including supply chain

Sector	England	Wales	Scotland	Northern Ireland	Total
Energy-efficient lighting	12,900	600	1,100	*	14,600
Insulation	31,400	2,500	1,700	400	36,000
Energy-efficient windows and doors	15,000	2,100	300	100	17,500
Heat recovery and ventilation	7,600	900	800	100	9,400
Energy controls and control systems	11,800	400	600	100	12,800
Sustainable architecture and buildings	3,600	300	100	*	4,000
Energy efficiency products	82,200	6,800	4,500	700	94,200

Source: TBR
Note. * indicates data is suppressed to prevent identification of individual businesses

Figure 16: Regional and national distribution of employment in energy efficiency products, 2013



Source: TBR

8 Low carbon services

This section presents key findings from the analysis of the size and performance of the Low carbon services sector group. This is a relatively small grouping that stands out in that it is involved in the provision of services only. The group comprises two sectors:

- Low carbon advisory services – this is broad ranging and includes businesses that provide general advice about low carbon, specialist engineering services and support services that are clearly provided to assist the low carbon economy.
- Low carbon finance – this sector has been drawn relatively tight and only includes activities associated with raising finance for low carbon projects.

Low carbon finance falls into two groups: providing finance for low carbon projects, e.g. asset finance; and equity and debt finance for companies operating in the low carbon economy. A third group was also found in terms of organisations providing information on grants and incentives. However, those providing services about domestic dwellings tended to be from the public sector and were doing so as part of a wider social remit, and as a result, they were excluded from the analysis. Firms offering these services to commercial clients also did so as part of other packages of assistance so were included within their principal sectors, e.g. solar PV.

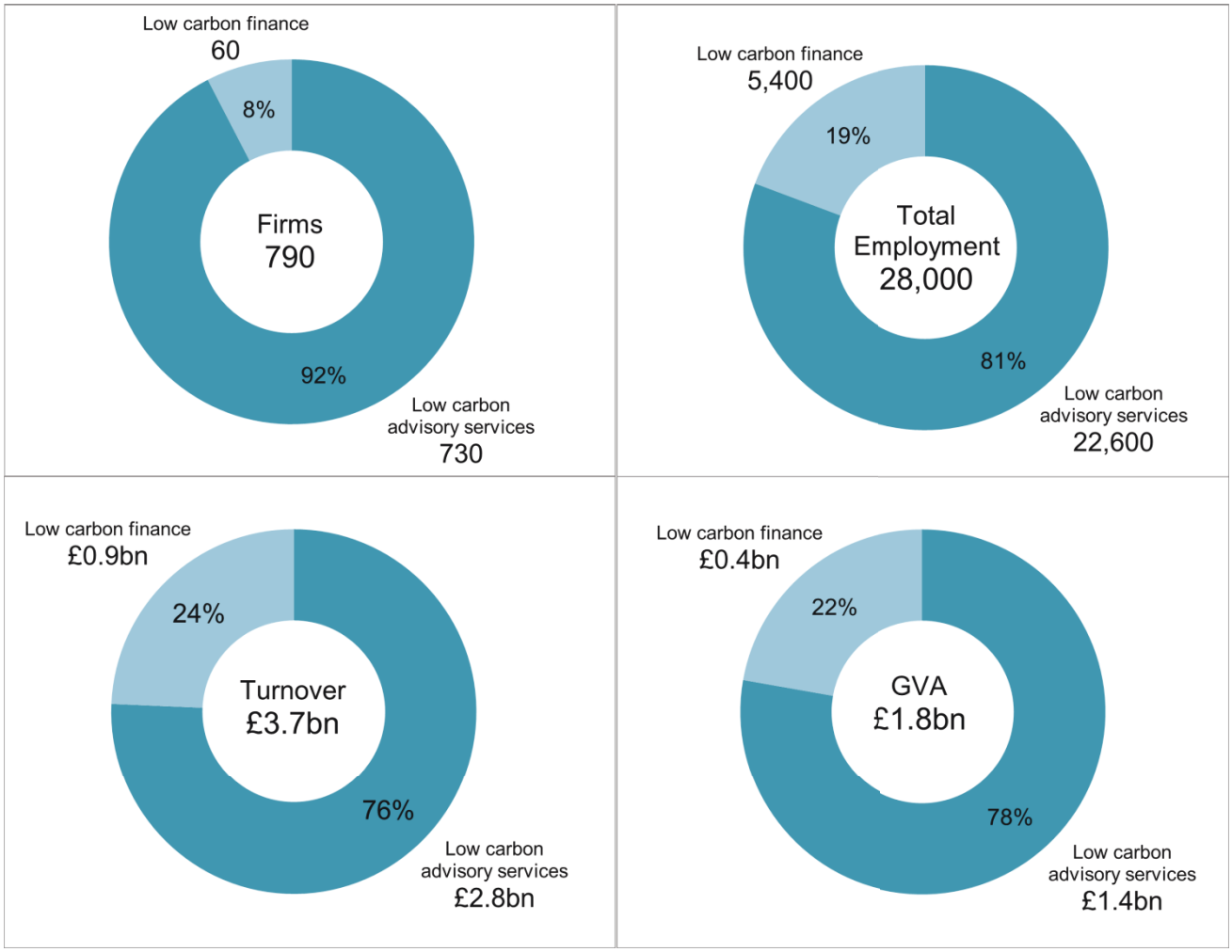
The full set of analysis can be located in the Appendix I - Full data tables.

8.1 Size and scale

- Overall this sector represents 7% of firms within the low carbon economy. Its contribution to employment is marginally lower (6%) but the significance of the sector within the wider low carbon economy reduces further when financial data is considered. The sector represents 3% of turnover (£3.7bn) and 4% of GVA (£1.8bn).
- There are relatively few organisations (60[53], equivalent to 8% of the group total) providing funding and specialist financial expertise specifically for the low carbon economy. There are many more businesses offering low carbon advice (730, equivalent to 92% of the group total).
- While the group is small, it is still responsible for employing nearly 28,000 people.
- Despite businesses offering advisory services being more numerous, they tend to be smaller than those providing finance, so only represent 81% of total employment, rather than the 92% suggested by firm numbers. The small size of some advisory firms was reflected in the qualitative interviews, where we spoke to several sole practitioners.
- The difference in size between the advisory and finance businesses is made more explicit in terms of turnover and GVA. Advisory firms generate 76% and 78% of the group's turnover and GVA, respectively.
- The range of advice provided by the advisory services is particularly wide. Three main areas of expertise were identified: engineering and other technical; legal and accounting; and commercial.

[53] These are firms operating directly in the low carbon economy and do not include the supply chain.

Figure 17: Firms, Employment, Turnover and GVA in low carbon services and its supply chain, 2013



Source: TBR

8.2 Performance

- Over the three year period from 2010 to 2013, employment levels within the group were effectively static. Low carbon advisory services grew very marginally but this was balanced out by a more significant percentage decline in employment in low carbon finance (-0.8%). However, the absolute numbers, especially for low carbon finance, are small so that relatively minor changes appear as more significant percentages.
- Analysis of the year on year data provides no discernible trend, with small downwards fluctuations in 2010-11 and 2012-13 and a small growth in 2011-12. Advisory shrank in 2010-11, but grew in the following two years whereas finance grew employment in the first two years but then shed jobs in 2012-13. This pattern of volatility is unlike any of the other groups in the low carbon economy but it is important to recognise that changes have involved small numbers of jobs.
- One possible explanation, for which there is no clear and specific evidence, is based on the nature of many of the businesses which operate in low carbon advisory services. A significant proportion of firms in the sector are large multi-disciplinary consultancies that operate across many sectors, most of them non-low carbon. Thus a change in the mix

of work could result in low carbon apparently shrinking or growing, even if overall employment is static.

- Turnover levels have grown by a compound annual rate of 3.1% which indicates a degree of real growth. GVA, on the other hand, has only grown by a compound rate of 0.9% per annum which suggests that the sector is struggling to improve output, though productivity appears to be rising as GVA has grown against static employment.
- Neither the survey nor the qualitative interviews provided any detailed insights into underlying drivers. However, several respondents did note that changes to government policy had resulted in uncertainty and potential projects either being withdrawn or becoming unfundable. Thus the performance of the low carbon finance sector is likely to be derived from the nature of the projects, rather than any endogenous cause.

Table 23: Low carbon services – employment history, including supply chain

Sector	2010	2011	2012	2013	CAGR % ('10-'13)
Low carbon advisory services	22,500	21,700	22,100	22,600	0.1%
Low carbon finance	5,600	5,900	6,100	5,400	-0.8%
Low carbon services	28,100	27,500	28,200	28,000	-0.1%

Source: TBR

Table 24: Low carbon services – turnover (£m nominal) history, including supply chain

Sector	2010 (£m)	2011 (£m)	2012 (£m)	2013 (£m)	CAGR % ('10-'13)
Low carbon advisory services	2,500	2,400	2,600	2,800	3.9%
Low carbon finance	900	900	1,000	900	0.6%
Low carbon services	3,400	3,300	3,600	3,700	3.1%

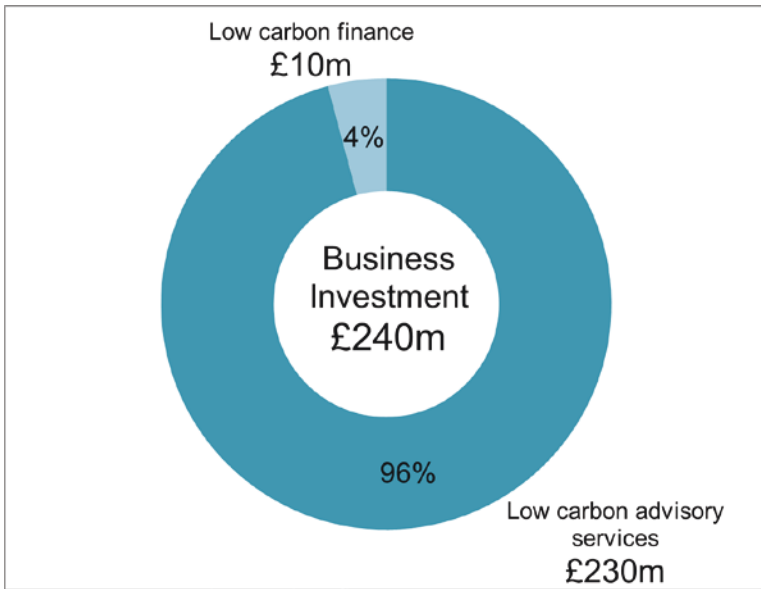
Source: TBR

Table 25: Low carbon services – GVA (£m nominal) history, including supply chain

Sector	2010 (£m)	2011 (£m)	2012 (£m)	2013 (£m)	CAGR % ('10-'13)
Low carbon advisory services	1,400	1,300	1,400	1,400	1.6%
Low carbon finance	400	400	500	400	-1.6%
Low carbon services	1,800	1,700	1,800	1,800	0.9%

Source: TBR

Figure 18: Business Investment in low carbon services, 2013



Source: TBR

- Business investment totalled £240m in 2013 and this was dominated by firms in low carbon advisory services, which invested £230m or 96% of the group total.

8.3 Spatial distribution

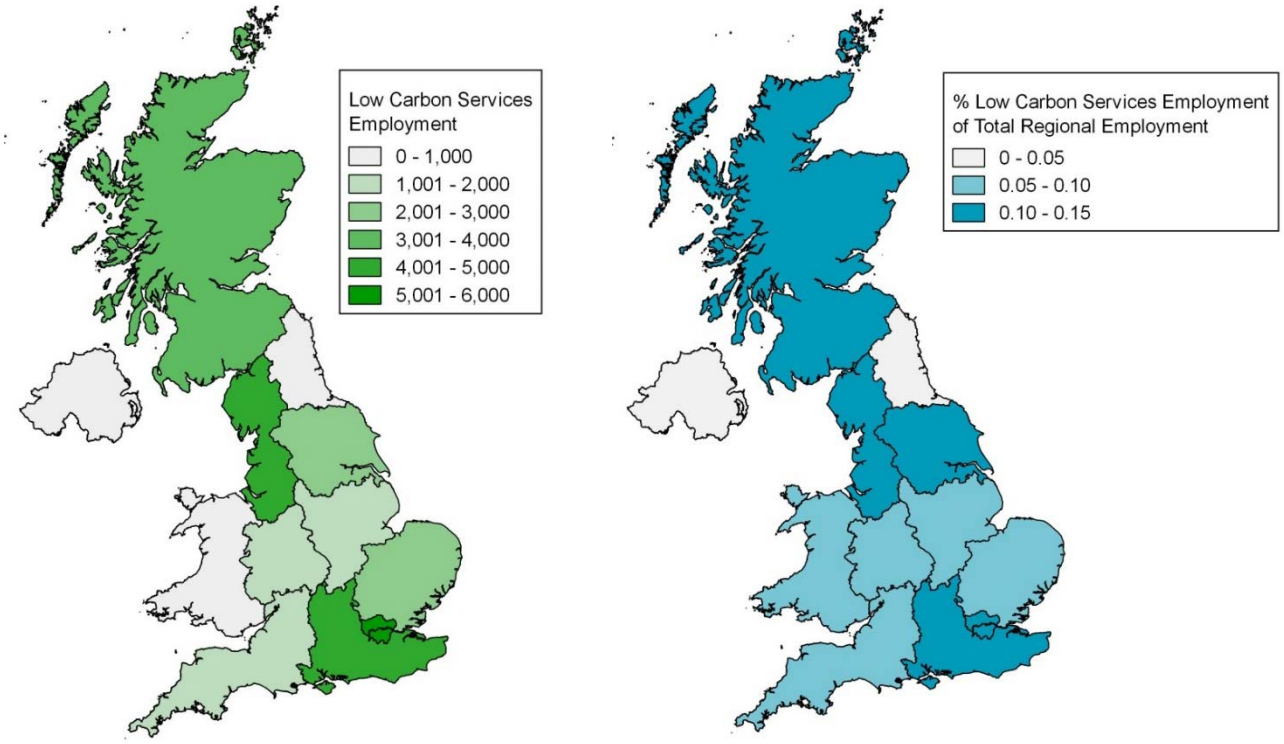
- Low carbon advisory services appear to be concentrated in England (93%), with relatively low numbers based in the devolved administrations.
- Low carbon finance is more evenly spread, though Scotland, at 10%, appears to have an overrepresentation of around a quarter.
- Within England, low carbon advisory services are concentrated in the West Midlands and the South East. The North West and South East are the principal areas for low carbon finance. London does not appear to be a centre of finance for low carbon, though this may be a function of major business investment being channelled through organisations that are not specifically low carbon, e.g. mainstream equity and debt providers, and thus not included in the definition.

Table 26: Low carbon services – national distribution of employment, including supply chain

Sector	England	Wales	Scotland	Northern Ireland	Total
Low carbon advisory services	18,800	600	3,100	100	22,600
Low carbon finance	5,100	100	300	*	5,400
Low carbon services	23,800	700	3,400	100	28,000

Source: TBR
Note. * indicates data is suppressed to prevent disclosure

Figure 19: Regional and national distribution of employment in low carbon services, 2013



Source: TBR

9 Low emission vehicles

This section presents key findings from the analysis of the size and performance of the low emission vehicles (LEV) sector.

The full set of analysis can be located in the Appendix I - Full data tables.

As this chapter is concerned with only a single sector, the approach to data presentation in this chapter differs from those that precede it.

9.1 Size and scale

- The low emission vehicles sector is relatively small in terms of the number of firms, with only 150 firms (1% of all firms in the low carbon sector) making it their primary area of activity. However, the sector and its supply chain employs 18,100 people across the UK.
- The LEV sector is populated by a wide range of businesses; ranging from the multinational car makers, e.g. Ford and small specialist producers such as Amalyst, a university spin-out company developing high performance catalysts. Despite the apparently small size of the group based on the number of firms involved in direct activities, its impact on the low carbon sector is significant in terms of economic activity. The group contributes 7% of turnover and 4% of total GVA for low carbon.

Figure 20: Firms, Employment, Turnover and GVA in low emission vehicles, 2013, including supply chain

Metric	Total LEV	% of low carbon economy
Firms (direct sector only)	150	1.3%
Employment	18,100	3.9%
Turnover (£m)	£8,800	5.3%
GVA (£m)	£1,700	8.7%
Investment (£m)	£80	2.2%

Source: TBR

- The data for the low emission vehicle sector is largely driven by the operations of the large car manufacturers. As such, deriving detailed analysis of business investment in their low carbon activities is challenging[54].
- Much of the business investment data are confidential or provided directly by the overseas parent companies so not included in the accounts of UK businesses. An estimate of £150m for business investment in low emission vehicles has been generated using Annual Business Survey (ABS) data.
- As the infrastructure for electric vehicles becomes more widespread, the use of this form of low emission vehicles is expected to increase. A similar situation is envisaged

[54] This was one of the reasons for using ABS data to estimate investment, rather than relying solely on survey data.

for hydrogen fuel cell vehicles, where this technology is confined, at present, to commercial vehicles, buses and taxis.

9.2 Performance

- Low emission vehicles include the design and manufacture of vehicles using plug-in electric, hydrogen fuel cell and standard 'parallel' electric hybrid power sources. While standard hybrid systems are now widely in use, they still only represent a small proportion of all cars manufactured and sold in the UK. Plug-in electric and hydrogen fuel cell vehicles, while in production, made up an even smaller fraction of one percent of UK output in 2013.
- While the production of LEVs represents only a small proportion of total output, it is a key focus of the R&D effort. Many key manufacturers are undertaking efforts to develop LEVs using the full range of technologies.
- Estimating the extent of the effort and returns in terms of employment, turnover and GVA proved challenging for the large car makers, e.g. JLR and Ford as they do not make this disaggregated data public. As such, estimates have been made based on data from the Society of Motor Manufacturers and Traders (SMMT) and reviews of the models produced and sold in the UK.
- The low emission vehicle sector has grown between 2010 and 2013 on all three measures. Perhaps most significantly, it is growing the terms of turnover at a compound rate of 5.3% per annum and GVA at a compound rate of 8.7%. This suggests that revenues and output are increasing as the volume of products becoming available in the market is also increasing.

Table 27: Low emission vehicles – employment, turnover (£m) and GVA (£m) history, including supply chain

Sector	2010	2011	2012	2013	CAGR % ('10-'13)
Employment	16,100	19,000	18,200	18,100	3.9%
Turnover (£m)	7,500	7,700	7,900	8,800	5.3%
GVA (£m)	1,300	1,300	1,600	1,700	8.7%

Source: TBR

9.3 Spatial distribution

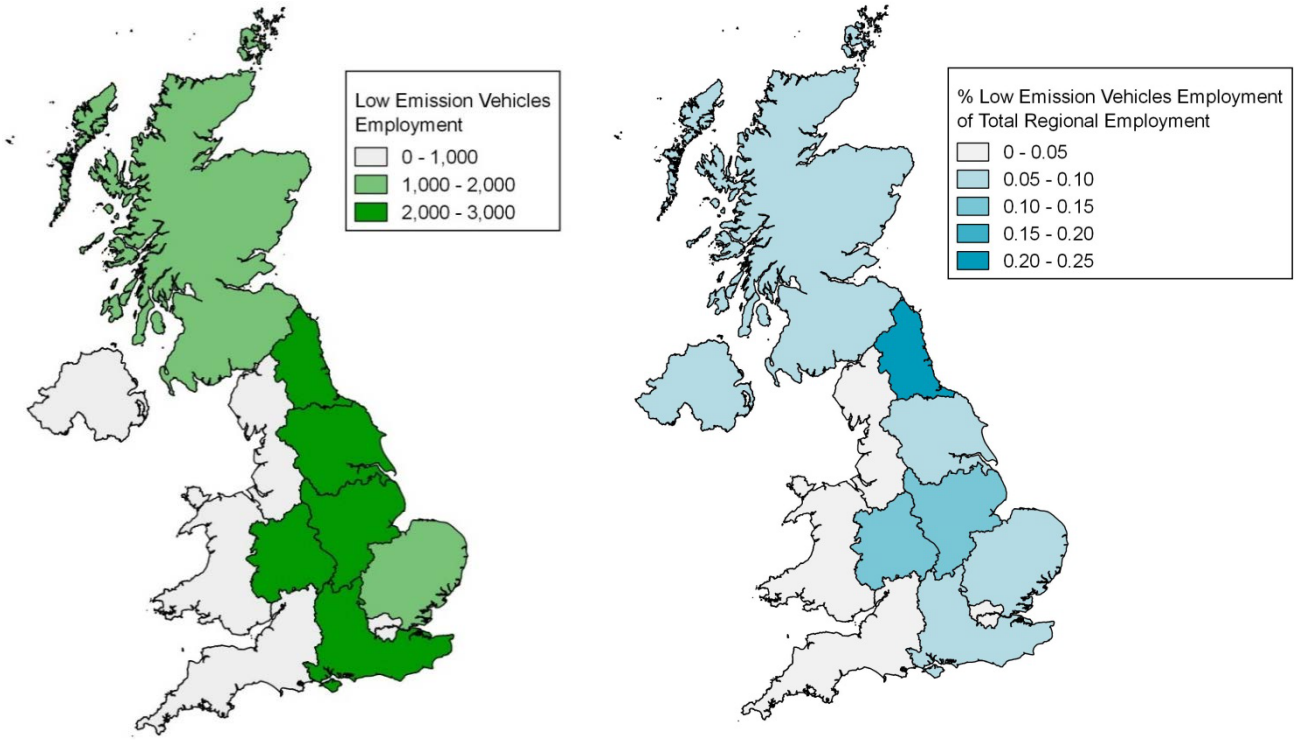
- At present employment in low emission vehicles is mainly concentrated in England.
- Employment related to the design and manufacture of vehicles is largely based in and around the existing car plants and supply chains.

Table 28: Low emission vehicles – regional distribution of employment 2013, including supply chain

Sector	England	Wales	Scotland	Northern Ireland	Total
Low emission vehicles	15,600	400	1,700	400	18,100

Source: TBR

Figure 21: Regional and national distribution of employment in low emission vehicles, 2013



Source: TBR

10 Appendices

10.1 Appendix I - Full data tables

Please see the next page for notes.

Table 29: Firm numbers by sector, 2013

Sector	Primary Sector Firms	Primary Percent	Operational Sector Firms
Onshore wind	300	3%	830
Offshore wind	220	2%	400
Nuclear energy	310	3%	490
Hydroelectric energy	90	<1%	300
Marine	50	<1%	210
Solar PV	2,380	21%	3,190
Energy generation from waste and biomass	150	1%	980
Carbon capture and storage	20	<1%	220
Biomass equipment	390	3%	1,700
Geothermal	40	<1%	550
Heat pumps	950	8%	1,640
Solar thermal	80	<1%	910
Heat networks	*	*	340
Energy-efficient lighting	290	3%	960
Insulation	760	7%	1,210
Energy-efficient windows and doors	180	2%	570
Heat recovery and ventilation	80	<1%	660
Energy controls and control systems	280	2%	1,210
Sustainable architecture and buildings	360	3%	580
Low carbon advisory services	730	6%	1,710
Low carbon finance	60	<1%	420
Recycling - recovery and reprocessing of materials from waste	3,040	26%	3,140
Alternative fuels	650	6%	1,290
Low emission vehicles	150	1%	460
Total firm numbers	**11,550**	**100%**	

Source: TBR

- The data in the table relates to direct activity only and excludes the supply chain. As part of the method firms were allocated to a single primary sector based on their main

activity. Thus the column headed Primary Sector Firms sums to 11,500. However, as many businesses operate across more than on sector (operational sector) firms may be counted more than once in the Operational Sector column.

- An asterisk '*' indicates that data have been suppressed to prevent disclosure. "<1" indicates that the share of primary firms for that sector is less than one per cent.

Table 30: Employment by sector[55], 2013

Sector	Direct Employment	Indirect Employment	Total Employment
Onshore wind	11,000	8,000	19,000
Offshore wind	7,900	5,800	13,700
Nuclear energy	37,500	21,500	59,000
Hydroelectric energy	4,300	3,100	7,400
Marine	1,800	1,300	3,100
Solar PV	20,300	14,100	34,400
Energy generation from waste and biomass	12,500	9,300	21,900
Carbon capture and storage	2,400	1,700	4,100
Biomass equipment	6,800	4,900	11,700
Geothermal	2,000	1,500	3,500
Heat pumps	13,600	9,200	22,700
Solar thermal	3,000	2,100	5,200
Heat networks	700	500	1,200
Energy-efficient lighting	8,900	5,700	14,600
Insulation	20,400	15,600	36,000
Energy-efficient windows and doors	9,500	7,900	17,500
Heat recovery and ventilation	5,500	3,900	9,400
Energy controls and control systems	7,900	5,000	12,800
Sustainable architecture and buildings	2,200	1,700	4,000
Low carbon advisory services	13,900	8,700	22,600
Low carbon finance	3,500	2,000	5,400
Recycling - recovery and reprocessing of materials from waste	53,000	40,500	93,500
Alternative fuels	11,600	8,300	19,800
Low emission vehicles	9,500	8,600	18,100
Total Low carbon	**269,800**	**190,800**	**460,600**

Source: TBR

[55] Some differences in sector totals and CAGR due to rounding to the nearest 100.

Table 31: Employment change by sector[56], including supply chain

Sector	2010	2011	2012	2013	CAGR % (2010-2013)
Onshore wind	14,300	17,800	18,400	19,000	10.0%
Offshore wind	10,900	11,600	12,400	13,700	8.0%
Nuclear energy	54,000	55,100	57,400	59,000	3.0%
Hydroelectric energy	6,800	7,300	7,100	7,400	2.9%
Marine	3,000	3,100	3,000	3,100	1.5%
Solar PV	19,500	28,800	35,600	34,400	20.8%
Energy generation from waste and biomass	20,100	20,100	20,600	21,900	2.8%
Carbon capture and storage	4,000	3,900	4,000	4,100	1.2%
Biomass equipment	10,900	11,700	11,700	11,700	2.2%
Geothermal	2,700	2,900	3,200	3,500	8.5%
Heat pumps	20,900	21,200	21,900	22,700	2.9%
Solar thermal	4,600	4,800	5,100	5,200	4.0%
Heat networks	1,000	1,100	1,100	1,200	3.8%
Energy-efficient lighting	14,300	14,300	14,500	14,600	0.6%
Insulation	32,700	33,600	34,400	36,000	3.2%
Energy-efficient windows and doors	16,800	16,400	17,000	17,500	1.3%
Heat recovery and ventilation	9,500	9,500	9,500	9,400	-0.4%
Energy controls and control systems	14,900	15,400	14,100	12,800	-4.9%
Sustainable architecture and buildings	3,900	4,200	4,300	4,000	0.8%
Low carbon advisory services	22,500	21,700	22,100	22,600	0.1%
Low carbon finance	5,600	5,900	6,100	5,400	-0.8%
Recycling - recovery and reprocessing of materials from waste	85,200	86,200	89,600	93,500	3.2%
Alternative fuels	17,100	17,800	18,700	19,800	5.0%
Low emission vehicles	16,100	19,000	18,200	18,100	3.9%
Total low carbon	**411,400**	**433,100**	**450,300**	**460,600**	**3.8%**

Source: TBR

[56] Some differences in sector totals and CAGR due to rounding to the nearest 100.

Table 32: Turnover by sector[57], 2013 (£m nominal)

Sector	Direct Turnover (£m)	Indirect Turnover (£m)	Total Turnover (£m)
Onshore wind	3,600	2,700	6,300
Offshore wind	2,000	1,500	3,500
Nuclear energy	7,700	4,400	12,100
Hydroelectric energy	1,100	800	1,900
Marine	200	200	400
Solar PV	5,000	3,500	8,400
Energy generation from waste and biomass	2,400	1,800	4,100
Carbon capture and storage	400	200	600
Biomass equipment	1,500	1,100	2,500
Geothermal	500	300	800
Heat pumps	1,900	1,300	3,100
Solar thermal	500	300	800
Heat networks	100	100	200
Energy-efficient lighting	2,100	1,400	3,500
Insulation	3,100	2,400	5,500
Energy-efficient windows and doors	1,500	1,300	2,800
Heat recovery and ventilation	900	600	1,500
Energy controls and control systems	1,400	900	2,200
Sustainable architecture and buildings	500	400	900
Low carbon advisory services	1,700	1,100	2,800
Low carbon finance	600	300	900
Recycling - recovery and reprocessing of materials from waste	12,400	9,500	21,800
Alternative fuels	15,200	10,900	26,100
Low emission vehicles	4,600	4,200	8,800
Total Low carbon	**70,800**	**50,900**	**121,700**

Source: TBR

[57] Some differences in sector totals and CAGR due to rounding to the nearest £100m

Table 33: Turnover change by sector[58], (£m nominal), including supply chain

Sector	2010 (£m)	2011 (£m)	2012 (£m)	2013 (£m)	CAGR % (2010-2013)
Onshore wind	5,400	7,000	5,700	6,300	5.3%
Offshore wind	3,300	3,100	3,100	3,500	2.5%
Nuclear energy	10,200	10,700	11,500	12,100	6.0%
Hydroelectric energy	1,700	1,900	1,800	1,900	4.5%
Marine	400	300	400	400	5.5%
Solar PV	6,000	5,400	6,200	8,400	11.9%
Energy generation from waste and biomass	3,800	3,500	4,000	4,100	3.2%
Carbon capture and storage	700	1,000	800	600	-3.4%
Biomass equipment	2,100	2,000	2,200	2,500	6.5%
Geothermal	600	500	600	800	12.0%
Heat pumps	2,700	2,700	2,800	3,100	4.5%
Solar thermal	700	800	800	800	3.4%
Heat networks	100	100	100	200	6.4%
Energy-efficient lighting	3,800	3,300	3,100	3,500	-2.5%
Insulation	4,800	4,700	5,100	5,500	4.7%
Energy-efficient windows and doors	3,100	2,700	2,800	2,800	-3.5%
Heat recovery and ventilation	1,500	1,400	1,500	1,500	-0.4%
Energy controls and control systems	1,900	1,900	2,100	2,200	5.1%
Sustainable architecture and buildings	900	900	900	900	0.8%
Low carbon advisory services	2,500	2,400	2,600	2,800	3.9%
Low carbon finance	900	900	1,000	900	0.6%
Recycling - recovery and reprocessing of materials from waste	18,700	15,900	19,000	21,800	5.3%
Alternative fuels	14,400	13,600	18,500	26,100	21.9%
Low emission vehicles	7,500	7,700	7,900	8,800	5.3%
Total low carbon	**97,500**	**94,600**	**104,400**	**121,700**	**7.6%**

Source: TBR

[58] Some differences in sector totals and CAGR due to rounding to the nearest £100m

Table 34: GVA by sector[59], 2013 (£m nominal)

Sector	Direct GVA (£m)	Indirect GVA (£m)	Total GVA (£m)
Onshore wind	1,000	700	1,700
Offshore wind	600	400	1,000
Nuclear energy	2,200	1,300	3,500
Hydroelectric energy	400	300	600
Marine	100	100	100
Solar PV	1,900	1,300	3,300
Energy generation from waste and biomass	700	500	1,200
Carbon capture and storage	100	100	200
Biomass equipment	600	400	1,000
Geothermal	200	100	300
Heat pumps	600	400	1,000
Solar thermal	200	100	300
Heat networks	*	*	100
Energy-efficient lighting	1,000	600	1,600
Insulation	1,100	900	2,000
Energy-efficient windows and doors	700	600	1,200
Heat recovery and ventilation	400	300	700
Energy controls and control systems	700	400	1,100
Sustainable architecture and buildings	400	300	700
Low carbon advisory services	900	500	1,400
Low carbon finance	300	100	400
Recycling - recovery and reprocessing of materials from waste	3,500	2,700	6,200
Alternative fuels	7,900	5,600	13,600
Low emission vehicles	900	800	1,700
Total Low carbon	**26,200**	**18,700**	**44,900**

Source: TBR

[59] Some differences in sector totals and CAGR due to rounding to the nearest £100m

Table 35: GVA change by sector[60], (£m nominal), including supply chain

Sector	2010 (£m)	2011 (£m)	2012 (£m)	2013 (£m)	CAGR % (2010-2013)
Onshore wind	1,200	1,400	1,800	1,700	11.5%
Offshore wind	600	800	1,000	1,000	16.9%
Nuclear energy	3,300	3,500	3,800	3,500	2.8%
Hydroelectric energy	700	800	700	600	-2.1%
Marine	100	100	100	100	13.3%
Solar PV	2,700	2,100	2,300	3,300	6.3%
Energy generation from waste and biomass	1,200	1,200	1,500	1,200	-1.2%
Carbon capture and storage	300	400	300	200	-7.3%
Biomass equipment	800	900	900	1,000	8.1%
Geothermal	200	200	300	300	11.0%
Heat pumps	1,000	900	1,000	1,000	1.5%
Solar thermal	200	300	300	300	3.6%
Heat networks	100	100	100	100	6.9%
Energy-efficient lighting	1,700	1,300	1,200	1,600	-0.9%
Insulation	1,800	1,800	1,800	2,000	3.9%
Energy-efficient windows and doors	1,500	1,100	1,200	1,200	-5.5%
Heat recovery and ventilation	700	600	600	700	2.1%
Energy controls and control systems	800	800	900	1,100	10.6%
Sustainable architecture and buildings	600	500	500	700	2.7%
Low carbon advisory services	1,400	1,300	1,400	1,400	1.6%
Low carbon finance	400	400	500	400	-1.6%
Recycling - recovery and reprocessing of materials from waste	5,500	4,700	5,600	6,200	4.0%
Alternative fuels	7,000	6,600	9,300	13,600	24.4%
Low emission vehicles	1,300	1,300	1,600	1,700	8.7%
Total low carbon	**35,000**	**32,900**	**38,600**	**44,900**	**8.7%**

Source: TBR

[60] Some differences in sector totals and CAGR due to rounding to the nearest £100m

Table 36: Employment by country[61], 2013, including supply chain

Sector	England	Wales	Scotland	Northern Ireland	Total
Onshore wind	12,800	600	5,400	300	19,000
Offshore wind	10,900	400	2,100	400	13,700
Nuclear energy	50,300	900	7,600	200	59,000
Hydroelectric energy	5,400	200	1,700	*	7,400
Marine	2,000	100	1,000	*	3,100
Solar PV	28,700	2,000	3,200	400	34,400
Energy generation from waste and biomass	20,400	300	900	300	21,900
Carbon capture and storage	3,500	*	600	*	4,100
Biomass equipment	9,800	400	1,100	500	11,700
Geothermal	2,700	100	600	*	3,500
Heat pumps	18,300	900	3,100	400	22,700
Solar thermal	3,800	200	1,100	100	5,200
Heat networks	900	*	100	*	1,200
Energy-efficient lighting	12,900	600	1,100	*	14,600
Insulation	31,400	2,500	1,700	400	36,000
Energy-efficient windows and doors	15,000	2,100	300	100	17,500
Heat recovery and ventilation	7,600	900	800	100	9,400
Energy controls and control systems	11,800	400	600	100	12,800
Sustainable architecture and buildings	3,600	300	100	*	4,000
Low carbon advisory services	18,800	600	3,100	100	22,600
Low carbon finance	5,100	100	200	*	5,400
Recycling - recovery and reprocessing of materials from waste	84,200	2,700	4,000	2,700	93,500
Alternative fuels	16,200	600	2,800	200	19,800
Low emission vehicles	15,600	400	1,700	400	18,100
Total Low carbon	**391,700**	**17,300**	**44,800**	**6,800**	**460,600**

Source: TBR

[61] Employment stated here includes headcount in both direct activities and supply chain.

Table 37: Employment by English Region[62], 2013, including supply chain

Sector	North East	North West	Yorkshire and the Humber	East Midlands	West Midlands	East of England	London	South East	South West	England
Onshore wind	700	1,400	2,100	1,400	1,300	1,000	1,100	2,500	1,200	12,800
Offshore wind	1,700	1,000	500	200	1,000	2,300	2,300	800	1,200	10,900
Nuclear energy	2,100	27,100	500	5,300	400	3,200	500	5,200	6,100	50,300
Hydroelectric energy	500	1,500	1,400	100	100	100	700	900	100	5,400
Marine	100	300	100	100	100	300	100	700	200	2,000
Solar PV	1,700	5,400	2,900	2,800	4,100	2,600	3,100	3,300	2,800	28,700
Energy generation from waste and biomass	1,500	2,900	1,400	800	1,100	900	3,100	7,100	1,600	20,400
Carbon capture and storage	*	1,500	100	100	300	100	300	900	100	3,500
Biomass equipment	300	1,000	1,500	1,000	1,300	1,200	800	1,700	1,000	9,800
Geothermal	400	200	200	100	200	700	500	200	100	2,700
Heat pumps	1,600	2,300	1,400	1,200	2,200	2,100	1,400	3,600	2,400	18,300
Solar thermal	200	500	300	300	500	700	300	500	600	3,800
Heat networks	100	100	100	100	100	200	100	200	100	900
Energy-efficient lighting	200	1,100	700	700	1,000	2,900	900	5,000	300	12,900
Insulation	2,600	6,300	3,500	6,800	3,900	3,100	1,000	2,300	1,800	31,400
Energy-efficient windows and doors	200	4,700	700	600	5,200	2,000	400	700	500	15,000
Heat recovery and ventilation	200	1,400	400	400	1,000	1,300	700	1,800	400	7,600
Energy controls and control systems	200	1,300	500	400	700	700	400	7,200	400	11,800
Sustainable architecture and buildings	100	200	200	300	500	700	200	1,200	200	3,600
Low carbon advisory services	400	2,600	2,100	1,500	1,100	2,000	3,500	4,200	1,500	18,800
Low carbon finance	*	1,500	200	100	700	100	1,600	600	300	5,100
Recycling - recovery and reprocessing of materials from waste	2,100	14,900	9,800	7,000	9,900	6,600	13,700	15,800	4,400	84,200
Alternative fuels	1,400	1,100	2,600	1,400	1,700	1,700	1,700	3,700	1,000	16,200
Low emission vehicles	2,300	500	2,200	2,400	2,700	1,800	700	2,800	200	15,600
Total Low carbon	**20,600**	**80,500**	**35,200**	**35,000**	**41,100**	**38,400**	**39,200**	**73,000**	**28,600**	**391,700**

Source: TBR

- Star '*' denotes that data have been suppressed to avoid disclosure.
- Employment stated here includes headcount in both direct activities and supply chain.

[62] Some differences in sector totals and CAGR due to rounding to the nearest 100.

Table 38: Business investment by sector[63], 2013

Sector	Total business investment (£m)
Onshore wind	240
Offshore wind	170
Nuclear energy	830
Hydroelectric energy	30
Marine	30
Solar PV	150
Energy generation from waste and biomass	420
Carbon capture and storage	20
Biomass equipment	110
Geothermal	10
Heat pumps	60
Solar thermal	10
Heat networks	10
Energy-efficient lighting	40
Insulation	50
Energy-efficient windows and doors	20
Heat recovery and ventilation	20
Energy controls and control systems	100
Sustainable architecture and buildings	20
Low carbon advisory services	230
Low carbon finance	10
Recycling - recovery and reprocessing of materials from waste	800
Alternative fuels	120
Low emission vehicles	80
Total Low carbon	**3,580**

Source: TBR

[63] Investment by businesses covers only direct activities and not the supply chain.

10.2 Appendix II - Glossary

A range of terms are used within the report, defined below.

Term used in report	Definition or explanation
Employment	Total staff either employed directly by the businesses or as contractors. The units are people or headcount, rather than full time equivalents (FTEs).
Turnover	Total revenues generated from business activities.
Gross Value Added (GVA)	A measure of net output. This is calculated by adding: employment costs; depreciation and amortisation; and gross profit.
Business investment	All expenditure undertaken by businesses to create assets in the expectation that they will aid in generating revenues and profits in the future.
Investment	Expenditure by government, businesses and individuals on low carbon goods, services and infrastructure. This is not the same as business investment, which generally focuses on spending by private businesses on their own productive capacity.
Direct (activity)	Activity that is immediately connected to one or more of the low carbon sectors. This includes companies such as Siemens who manufacture wind turbines, Nissan electric vehicles, Springfields nuclear fuel and Argent Energy who manufacture biodiesel from animal carcasses.
Indirect (activity)	Activity undertaken for, or on behalf of, a business directly engaged in a low carbon sector, i.e. it is indirectly engaged. Although companies in the supply chain were not identified explicitly, their economic impact was modelled using multipliers – see below. Often, these businesses may be similar to those who operate directly in low carbon, in the sense that they may be manufacturers of engineering products and components, professional and technical services firms, chemicals suppliers, transport providers etc. However it also includes businesses providing generic materials such as stationery and services such as accounting or legal.
Carbon capture and storage (CCS)	Technology to capture and store or sequestrate carbon, usually in the form of carbon dioxide (CO_2) that is given off when generating electricity from fossil fuels or as part of industrial processes, e.g. production of iron and steel and chemicals.
Solar photovoltaic (PV)	Solar PV is used to generate electricity from sunlight.

Term used in report	Definition or explanation
Supply chain	The supply chain to a sector represents all firms that provide the goods and services which underpin the activities in the sector itself. In the context of this report, the supply chain to a low carbon sector is the same as the indirect activity that the sector generates
Type I multiplier	Factor used to estimate the size of indirect or supply chain activity based on data for direct elements.
Type II multiplier	Factor used to collectively estimate indirect and induced effects on the wider economy. Induced effects arise from the spending of wages and salaries of people directly and indirectly engaged in the sector. Note these are not used in this work.
Business databases	Data about businesses and their performance is drawn from two main sources (other than the survey). These are the Interdepartmental Business Register (IDBR) and Trends Central Resource (TCR). IDBR is the principal government database about businesses in the UK. The information it contains is drawn from across government, with HMRC (VAT, PAYE, and Corporation Tax) and Companies House being the main sources. TCR also uses data from Companies House, however the bulk of material is supplied by Dun & Bradstreet, an established commercial credit checking agency. Both databases have their advantages and drawbacks. IDBR has obvious credentials as the key 'official' source. TCR benefits by including many more small, unincorporated firms, especially those who are not registered for VAT or who do not operate payroll systems. TCR also contains historical data so is useful for undertaking analysis over time.
CAGR	Compound Annual Growth Rate is a notional rate that links data between two points in time. It represents a constant rate that applies over the time gap and seeks to smooth out annual fluctuations. It has an analogy in compound interest and Internal Rate of Return (IRR). It is calculated using the equation: $$r = \sqrt[n]{\frac{FV}{PV}} - 1$$ Where: r = The compound annual growth rate FV = The future value (e.g. in 2013) PV = The initial value (e.g. in 2010)

Term used in report	Definition or explanation
	n = The number of time units (years) (e.g. 3)
Primary sector	All businesses operating in the low carbon economy and captured in the population were allocated to a primary business sector. Allocation was based either on the sector responsible for most employment (firms that took part in the survey) or on an assessment from the firm's website.
Operating sector	The pilot survey work and review of websites identified that businesses often operate in more than one low carbon sector. These were referred to as operating sectors. Thus each firm had only one primary sector, but could have multiple operating sectors.

10.3 Appendix III – Detailed methodology

This section presents a detailed description of the method used to generate the data and information contained within the report. The key aims of the study were to devise and use a method that is transparent, open to scrutiny and can be replicated.

A key methodological difference compared with previous studies is the use of primary data collection, through running a survey of firms operating in the low carbon economy, whereas previous studies relied on using a combination of existing data sources.

The value of the survey data is that it provides an understanding of what proportion of activity for firms operating in the low carbon economy occurs in each of the 24 low carbon sectors and what proportion occurs in non-low carbon sectors. For example, for a company whose main business is in insulation, it would show to what extent they are involved in other sectors such as solar PV. Rather than the traditional method of surveying a sample of the population and weighting the total values collected up to the whole population, the survey was used to determine the spread of firms across low carbon and non-low carbon activities.

A database covering the population of firms considered to have full or partial involvement in each of the 24 low carbon sectors identified was constructed from existing sources, and included data on employment, turnover and GVA, as well as an assessment of the main low carbon sector of activity[64]. As such, the survey could then be used to reallocate activity within the population database of firms operating in the low carbon sector, so that the analysis estimates what activity from these firms actually falls within the 24 sectors identified in the low carbon economy.

The section methodology covers appendix is broken down into the following sub-sections:

- Requirements for the study
- Defining the low carbon economy
- High level groupings and sectors
- Direct and indirect activity
- Developing a methodology
- Constructing a population database
- Survey design and operation
- Survey response
- Data analysis
- Supply chain
- Investment data
- Trade data
- Strengths of the method
- Limitations of the method
- Scope for improvement

[64] Gross Value Added

Requirements for the study

The research specification for the delivery of this study contained the following components.

To develop a set of clear definitions of low carbon sectors. The low carbon sectors of interest include both "demand-side" components (e.g. building technologies, low emission vehicles) and "supply-side" technologies (e.g. nuclear power, wind power). Whilst the inclusion of both these sides of the low carbon economy was essential to this study, a further refinement was also called for.

For demand-side technologies it was deemed important to consider the rate at which these goods or technologies have become more low carbon over time. Only technologies that are considered as 'step-change' were to be included. Technologies that have incremental impacts on carbon emissions were to be excluded (such as conventional, lower emission vehicles). This requirement necessitated the design of an approach to defining 'step-change' technologies that could be readily and consistently applied.

Furthermore, the focus of this project is on "low carbon outputs" (e.g. wind turbines, energy efficient products), rather than on any "low carbon processes" (e.g. energy-efficient manufacturing) as these can take place within a typically non-low carbon sector (e.g. oil refining) and therefore again cannot unambiguously be classified as low carbon.

Therefore this is a narrower definition of the low carbon sector than used previously, and results from previous studies are not comparable.

To construct a transparent and updateable methodology to estimate the economic activity within those sectors. The priority for this study was to develop a transparent, quality assured view of a clearly defined "low carbon economy", with a future-proof methodology for providing annual updates. Therefore, it was envisaged that the new analysis would focus on a small number of clearly defined sectors or technologies that contribute to the UK's low carbon economy. These sectors are outlined below.

To apply this methodology to obtain a series of quantitative estimates of low carbon economic activity. The study focuses on delivering analysis of the size and performance of the low carbon economy over the period 2010 to 2013, to be delivered in a final report. The assessment covers the following key variables; number of firms, employment, turnover, GVA and business investment. The study is UK-wide but data for the four UK nations and nine English regions was also specified.

In order to address each of the components of the study the research team developed a detailed and wide-ranging methodology which was founded on the principals of creating clear definitions of low carbon sub-sectors, identifying the businesses that operate within the low carbon economy and then identifying the economic activity that these businesses undertook through their participation in the low carbon economy. This allowed the study to overcome the two key challenges in assessing the size and performance of the low carbon economy:

- The 'building blocks' commonly used in sector studies (e.g. Standard Industrial Classification codes and associated national statistics) are not readily applicable.

- The sector involves many businesses for which the low carbon economy represents just a proportion of their total economic output (e.g. electricity providers and car manufacturers).

Defining the low carbon economy

Providing a robust definition for the low carbon economy is challenging. There are many areas of economic activity that claim to be part of the low carbon economy. While for some, such as generating electricity from renewable sources, this claim may be fully justified, for others the case is less clear. For example, can motor cars capable of over 80 miles per gallon be deemed to be part of the low carbon economy as they clearly represent a significant improvement on what went before, or do they merely represent the results of incremental improvement to a technology that is inherently polluting?

The definition used in this study was developed against a set of explicit parameters and is open to review and scrutiny. The process for generating the definition is set out below:

- Start with an **initial list** of broad sectors put forward by government departments responsible for business, climate change and the environment.
- Categorisation of the broad sectors into two groups; those classed as being driven by **supply** factors, e.g. energy; and those where **demand** forms the key drivers, e.g. recycling and energy efficient products where a consumer is seeking a low carbon alternative to an existing product or service and can exercise some form of choice.
- For products deemed to be demand driven, only those activities where it is clear that a **step-change improvement** in carbon emissions or other environmental impact has been achieved are included. This test is intended to exclude products such as vehicles powered by combustion engines which still utilise an inherently polluting technology.

This produced a proposed list of sectors that defined the low carbon economy in the UK, which was subsequently submitted to Government for review. Based on feedback, including meetings with staff from Government departments, changes were made to the initial list of sectors, supply chains and inter-linkages. Furthermore, the detail of the activities undertaken in the sectors was refined as part of the consultations with businesses and other organisations operating in the low carbon economy.

High level groups and sectors

The low carbon economy has been classified into six high level groups. The groups are then disaggregated into 24 individual sectors. Some of the 24 sectors can be further split into sub-sectors. The basic details of the groupings and sectors are set out below in Table 39.

Table 39: Low carbon sectors and groups

Grouping	Sectors
1. Low carbon electricity	Onshore wind Offshore wind Nuclear energy Hydroelectric energy Marine energy Solar Photovoltaic (PV) Carbon capture and storage
2. Low carbon heat	Geothermal heat Heat pumps Solar thermal Heat networks
3. Waste processing, energy from waste and biomass	Recycling - recovery and reprocessing of materials from waste Generation of energy from waste and biomass. Alternative fuels Biomass equipment
4. Energy efficiency products	Energy-efficient lighting Insulation Energy-efficient windows and doors Heat recovery and ventilation Energy controls and control systems Sustainable architecture and buildings
5. Low carbon services	Low carbon advisory Low carbon finance
6. Other low carbon	Low emission vehicles

Source: TBR 2014

The brief made note that for demand led sectors, only those products and technologies based on some form of step-change should be included.

The sector groupings deemed to be demand led were:

- Energy efficiency products
- Waste processing
- Alternative fuels
- Low emission vehicles

These sectors were further investigated and defined based on the nature of the products and underlying technologies. Thus energy efficient lighting was defined as including only LED and compact fluorescent bulbs and luminaires.

Detailed descriptions of each of the 24 low carbon sectors are provided in Appendix IV.

Direct and indirect activity

The client group made clear that the definition should clearly identify those activities that were directly involved in low carbon as distinct from those in the supply chain. This was

achieved by investigating each of the sectors, identifying and capturing the key activities undertaken. These are all clearly associated with what might instinctively be deemed low carbon.

Indirect activities are those undertaken further down the supply chain, where the association with low carbon may be less clear, and in many instances may take place with industries identified as being non-low carbon. For example the standard method for producing hydrogen involves cracking methane (CH_4), a major output from the oil and gas sector. However, it is important to consider the supply chain activity which supports the low carbon economy.

The boundary between direct and indirect is best illustrated by example. For the offshore wind sector, the direct activities include:

- Design and manufacture of wind turbines.
- Design and manufacture of equipment associated with the wind turbines, e.g. offshore electricity hubs/sub-stations.
- Consultancy and research activities aimed at optimising the location and positioning of the wind turbines.
- Installation and commissioning of the wind turbines.
- Connecting the wind turbines to the power grid.
- Operation and maintenance of the wind turbines.
- Decommissioning of wind turbines.

Thus all these activities can be directly associated with the generation of electricity using offshore wind turbines. However, the manufacturers of wind turbines do not operate in isolation and need to purchase material inputs and services from their supply chain. This will include not just raw materials such as steel, but basic components such as fasteners and even specialist items such as electronics for measuring the performance of a turbine and transmitting the data to a control room. All these items will have uses in products other than low carbon. The availability and supply of these products (and services, such as training or environmental monitoring) are vital to supporting the low carbon economy.

The activities of the supply chain are referred to as indirect inputs[65].

Developing a methodology

The methodology is founded on the principle that a top-down assessment of the low carbon economy, based upon the analysis of aggregated data and using Standard Industrial Classification (SIC) codes, is not possible.

The common approach to defining and assessing a sector would be to use the SIC system to create a definition, then use government (or other) data to support the assessment, where that data are provided against relevant SIC codes. Such an approach would rely on the accuracy of SIC codes to define the sector, since relevant aggregated data on employment, value added and other economic variables (e.g. provided by the Office of

[65] The terms indirect activity and supply chain are used interchangeably. Thus all indirect activity takes place within the supply chain. The only exception would be where generic items, such as office sundries are supplied directly to the core activity, e.g. the operator of a wind farm.

National Statistics) is structured using SIC codes. It is well established that it is not possible to define the low carbon economy comprehensively and accurately using SIC codes (although some sub-sectors, such as waste, do align better than others).

The only other possible option would be to find a set of data which is already defined in a way which is entirely comparable with the current definition being applied to this project. Such a data source does not exist. It was agreed that the study should be founded on a bottom-up methodology which identifies companies that constitute the sector then investigate the extent to which their activity is undertaken within the low carbon economy.

However, a process which involves allocating companies to low carbon sectors is subject to a significant caveat. As firms may work in more than one sector at the same time, it seems not unreasonable to suggest that a company making generators for offshore turbines could supply similar ones for onshore turbines, then there is the possibility of counting any such company more than once. This would have the effect of over stating the size of each sector and hence the overall low carbon economy. Clearly, such a danger as double counting, needs to be avoided.

For the low carbon study this was achieved by allocating companies' activities (using employment as a proxy) to each sector that they work in, including non-low carbon. This process is discussed in more detail below.

Constructing a population database

There are two key data gathering elements to the method for estimating the size of the low carbon economy. These are:

- Identifying the population of firms operating in the low carbon economy (described here).
- Assessing the extent to which these companies participate in the low carbon economy and the related economic value – in terms of employment, turnover, GVA and other variables – of that participation (described below).

The first stage was to establish a range of data sources that could be used to identify firms operating in the low carbon economy. The principle applied was that for a business to be considered part of the low carbon economy, it must display characteristics or behaviours that associate it with that sector. For example, it might be a member of a trade association, manufacture products specified in the sector definitions or conform to an agreed line of business.

However, whilst participation in a particular SIC code or marketing of products and services can be seen as relatively robust methods of identifying the firms that participate in low carbon sectors, trade directories and membership lists are less reliable. For businesses to be included in the low carbon database they must be *actively* operating in a sector. Lists and directories can also cover businesses that aspire to operate in the sector or that wish to be included in such networks for other, strategic reasons (e.g. to understand competitor behaviour). For this reason, significant additional verification of candidate low carbon businesses was required.

The sources used to identify companies active in low carbon can be classified into three categories;

- Business datasets, such as TCR and IDBR where searches could be made using SIC codes or, in the case of TCR, key words.
- Membership lists, such as those published by trade associations
- Trade directories/publications, as published on the web.

An extensive desk research exercise was undertaken to identify the range of membership and trade bodies as well as directories that could be utilised. This process resulted in the identification of over 130 sources of data on companies operating within the low carbon economy.

In addition, TBR's longitudinal business dataset (described Appendix V – Trends Central Resource (TCR) was also employed to identify firms operating in low carbon sectors, utilising key word searches based on text descriptors of business activities. Finally, the Inter-Departmental Business Register, government's own dataset of firms, was also employed to identify additional firms and, importantly, local units (i.e. branch plants) for firms operating a distributed business model.

Data drawn from all available sources was collated into a database of over 25,000 'candidate' firms. However, in order to validate that firms participated in the low carbon economy, a process of review was undertaken. This involved verifying that each firm within the database undertook business activities that fell within the 'direct' activities of at least one of the 24 low carbon sectors. This was achieved through a review of websites. Very few firms lacked a website to support this validation process. However, it was decided that if it was not possible to positively affirm the participation of a firm in at least one low carbon sector, then that firm would not be included in the dataset.

At the completion of this process, the database contained a validated set of 11,550 business records including all identifiable branch plants. These firms were segmented into a 'primary' low carbon sector based on their most prominent and important business activity.

Having populated the dataset, additional data fields were included drawing data from TCR and IDBR. The final dataset included the following data fields:

- Company name
- Full address and postcode
- Key contacts (name, title)
- Phone number
- Nature of site (headquarters, single site, branch)
- Start year
- Employment (2010-2013 inclusive)
- Turnover[66] (2010-2013 inclusive)

[66] Historic financial data are available for firms where they report full accounts to Companies House (i.e. where their turnover is greater than £6.5m). It was decided not to ask for these data from small companies

- Gross Value Added[67] (2010-2013 inclusive)
- SIC codes
- Primary low carbon sector
- Line of business activity (free text)
- Trading names
- Ownership structure (independent, UK owned, foreign owned)

Survey design and operation

Having identified a population of businesses operating in the low carbon economy, the study then needed to establish the scale of participation in the sector.

Having identified the population of firms that operated across the sectors, primary research was undertaken. This was use to confirm that companies did in fact operate in one or more low carbon sectors and to collect information such as employment, turnover and other financial data.

The key elements of the survey work are outlined below:

- **Questionnaire.** A survey questionnaire was designed by the research team, in collaboration with Qa Research and agreed with the client. The questionnaire was designed to capture all required data. It validated participation in the low carbon economy and – importantly - captured data on the employment supported by activities across the low carbon sectors, thus recognising that firms can operate in more than one low carbon sector. It also allowed for the identification of employment and associated economic value (turnover, GVA, imports, exports and business investment) generated from non-low carbon sectors.
- **Survey samples.** These were created that sought to reflect the population as a whole. For the pilot survey a limited selection of 400 businesses was supplied. At this stage no quotas were set regarding sectors or firm size.
- **A pilot survey** was conducted and the results analysed. The results indicated that firms were prepared to participate but that the extent of the information that they were either willing or able to provide was limited. As a result the questionnaire was revised.
- **Sector quotas.** These were based on the estimated population of each of the low carbon sectors, and were established for the main survey. This was to ensure that a minimum number of firms operating in each low carbon sector were interviewed. However, a challenge faced in this regard was that the database of companies was not fully complete at the time, so there were no definitive numbers on sector size on which to base the quotas. Quotas were met in all sectors bar nuclear, which proved challenging because of the dominance of large firms[68].
- **Quotas for company size.** These were not set, and the results indicated that overall large and very large companies were under represented[69]. The deficiency was addressed during the analysis phase – see below.

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within the survey as it was deemed too onerous. Instead, available secondary historic data (from TCR) and historic data on employment provided by all firms was used to model trends in financial data.

[67] GVA is calculated by summing: profit before tax, employment costs, amortisation and depreciation.

[68] This was resolved by speaking to companies that may have been classified as being in the supply chain.

[69] These were companies with more than 250 and 1000 employees respectively.

- **Main survey**. A CATI[70] telephone survey of businesses operating directly in low carbon sectors was undertaken based on a sample of 4,240 companies (Directs survey). This, when combined with the pilot, generated 633 complete responses. The scale of the sector and the resources available to the project prevented a larger set of responses being obtained. However, this level of response was deemed suitable for the project.
- **Qualitative interviews.** Members of the TBR research team undertook in-depth interviews with over 75 businesses operating across the low carbon sectors. These aimed to gain additional evidence about the drivers of change.

Survey response

As indicated above a total of 633 complete responses was achieved, equivalent to a 15% response rate against the sample frame and 5.5% of the whole low carbon business population. This was considered good based on the nature and detail of information being requested.

The Qa CATI system allowed contact centre staff to call firms in the sample and work through a process that involved: achieving a willingness to take part; identifying the most appropriate person to speak to; booking a time to undertake the interview; alerting the participant of the information required and finally carrying out the interview. While the process appears lengthy, in some cases it was completed in the course of a single call. More often several calls were needed. Once six calls had been made to a single firm and no acceptance to participate gained, the record was expired and deleted from the list. This process increased the response rate for the sample while lowering the burden on business.

Details of the responses and quotas are provided below in Table 40. As can be seen, nuclear was the only sector where the quota was not achieved. This deficiency was addressed by undertaking more detailed desk research for firms in the nuclear sector – see note on large firms.

Data analysis

The survey data were analysed to establish the extent to which firms work across the low carbon sectors.

This was achieved via the following steps:

- **Allocate firms to a primary sector**. All firms in the low carbon database were allocated to a primary low carbon sector.
- **Group responses by primary sector.** The responses from the survey were grouped by primary sector.
- **Generate a profile of employment.** For each primary sector the level of employment across all the sectors was assessed. As businesses operate across multiple low carbon and the non-low carbon sectors, a mechanism was needed to establish a pattern for each of the primary sectors. For example, employment data were analysed for all firms categorised as being in onshore wind. This showed that:

[70] Computer-assisted telephone interviewing.

- 74% of their employment was in onshore wind
- 6% was in offshore wind
- 3% was in hydroelectric energy
- 3% was in solar PV
- 3% was in alternative fuels and
- 10% was in non-low carbon
- The remaining 1% was spread across the other sectors.

Table 40: Survey quotas and responses

Sector	Quota	Returns (operating sector)[71]
Alternative fuels	44	115
Biomass	24	107
Carbon capture and storage	8	38
Energy controls	16	54
Energy efficient windows	8	24
Geothermal	8	31
Heat pumps	24	49
Heat recovery ventilation	16	31
Hydroelectric	28	35
Insulation	16	59
Low carbon advisory services	64	244
Low carbon finance	16	70
Low emission vehicles	40	62
Energy efficient lighting	16	51
Nuclear	40	22
Offshore wind	48	57
Onshore wind	40	101
Energy generation from waste and biomass	12	65
Heat networks	8	33
Reprocessing glass	8	7
Reprocessing other materials	16	33
Reprocessing paper	8	17
Reprocessing plastics	8	17
Solar photovoltaic (PV)	24	172
Solar thermal	24	44
Sustainable architecture and buildings	16	18
Tidal range	10	34
Wave and tidal stream	10	34

Source: TBR

[71] One firm can have multiple operating sectors. Thus 633 firms were interviewed who provided 1624 responses at the level of the 24 operating sectors.

This profile of percentages was referred to as the employment coefficients or collectively as an employment profile. A total of 24 profiles was generated, one for each low carbon sector.

This approach ensured that double counting was prevented as firms were forced to allocate 100% of their employment to individual sectors including non-low carbon.

To assess the size of the low carbon economy, the firm population was divided into three groups:

- Firms that matched the survey population in terms of size.
- Survey respondents.
- Large companies (that were under represented in the survey) and those for whom more detailed data on their activities could be generated from other sources, e.g. company accounts.

Firms that matched the survey sample. For firms that matched the sample, their employment was summed and allocated to the low carbon sectors according to the coefficients within the profiles.

Firms in the survey. The data for each survey respondent was captured as is, so the application of coefficients was not required.

Large firms. For large firms the coefficients were not applied, rather efforts were made to investigate them on an individual basis. Examples included; the nuclear power stations operated by EDF, other large utilities generating electricity from low carbon sources and construction companies. This method countered the survey data being biased towards SMEs – see above and the failure to meet the survey quota for nuclear.

The employment profiles were also used to allocate turnover and GVA across the low carbon sectors. It is acknowledged that while employment is a useful proxy, turnover and GVA may not be allocated in exactly the same ratios as employment.

Supply chain

The method set out above was used to estimate the size of the direct low carbon economy. The size and value of the supply chain was estimated using the established method of applying multipliers.

Multipliers are a tool used by economists, statisticians and analysts to estimate overall impacts of economic activity or change. If there is an increase in final demand for a particular product, we can assume that there will be an increase in output of that product, as producers react to meet the increased demand; this is the direct effect. As these producers increase their output, there will also be an increase in demand on their suppliers and so on down the **supply chain**; this is the indirect effect. As a result of the direct and indirect effects the level of household income throughout the economy will increase as a

result of increased employment. A proportion of this increased income will be re-spent on final goods and services: this is the induced effect[72].

These multipliers are often referred to as:

- Type I – these attempt to assess supply chain impacts.
- Type II – these seek to assess induced effects, or those that result from the spending of employees on goods and services.

Only Type I multipliers were used. It was agreed that induced effects would not be included within the scope of the study.

The actual multipliers themselves are published by ONS, usually in a level of detail equivalent to two or three digit SIC codes and derived from the supply and use tables.

The key constituent activities for each of the sectors was reviewed and a Type I multiplier allocated based on an appropriate 2 digit SIC code. A composite multiplier was then generated using a simple average of the individual values.

The multiplier for offshore wind is presented below as an example:

Figure 22: Sample multiplier – Offshore wind

	Sub-sectors								
Offshore wind	**Develop't & consulting**	**Turbine manuf**	**Construct'n & civil works**	**Substat'n design & manuf**	**Turbine installation & commiss'g**	**Grid connect'n**	**Operations & maint'e**		**Total Offshore wind**
I/O Sector	71	28	41-43	27	33other/71	33other	33other		
I/O sector description	Architectural, and engineering activities; Technical testing and analysis	Machinery and equipment	Civil engineering	Electrical equipment	Rest of repair, installation/ Architectural, and engineering activities, technical testing and analysis	Rest of repair, installation	Rest of repair, installation		
Multiplier (Type I)	1.684	1.698	1.829	1.61	1.735	1.786	1.786		1.733

Source: TBR from ONS data

Note that multipliers were used to calculate the indirect impact of the low carbon economy for employment, turnover and GVA only. They were not employed in the estimates for business investment.

Full details of the multipliers used are provided in Table 41, below.

[72] http://www.scotland.gov.uk/Topics/Statistics/Browse/Economy/Input-Output/Mulitipliers

Table 41: Type I multipliers

Sector	Type I multiplier
Onshore wind	1.7
Offshore wind	1.7
Nuclear energy	1.6
Hydroelectric energy	1.7
Marine	1.7
Solar PV	1.7
Energy generation from waste and biomass	1.7
Carbon capture and storage	1.7
Biomass equipment	1.7
Geothermal	1.7
Heat pumps	1.7
Solar thermal	1.7
Heat networks	1.7
Energy-efficient lighting	1.6
Insulation	1.8
Energy-efficient windows and doors	1.8
Heat recovery and ventilation	1.7
Energy controls and control systems	1.6
Sustainable architecture and buildings	1.8
Low carbon advisory services	1.6
Low carbon finance	1.6
Recycling - recovery and reprocessing of materials from waste	1.8
Alternative fuels	1.7
Low emission vehicles	1.9

Source: TBR, developed from ONS Type I multipliers

Investment data

It was originally hoped that sufficient data could be gained from the survey to estimate the level of business investment by firms operating in the low carbon economy. However, the overall size of the survey along with the unwillingness/inability of firms to disclose/establish detailed data meant that the sample sizes were too small to allow robust values to be presented.

Following advice, ONS data from the Annual Business Survey was used to generate estimates of investment. The approach used is set out below:

Establish SIC profiles. The SIC codes (4/5 digit) of firms within each primary sector were investigated.

Weighted profile. Employment was used to establish the top ten SIC codes on a weighted basis.

Investment per employee. ABS data were reviewed to establish investment per employee for each of the SIC codes identified above.

Weighted investment per employee. The weighted profiles were applied to the ABS investment per employee data to generate a weighted investment per employee for each low carbon sector.

Investment per sector. The weighted investment per employee data were multiplied by direct employment in each low sector to calculate total business investment across the low carbon sectors.

This approach to estimating investment was reviewed by the Peer Review Panel and judged to represent a best available approach. However, there are two main limitations to the method. These are, concerns that:

- Employment intensity is not a perfect proxy for investment intensity, so the ABS data are not applied in the correct ratios.
- The allocation of SIC firms is imprecise, especially for firms that operate across a range of market segments.

Historical trends

The low carbon population of firms captured in the database was accurate as of 2013. However, similar population sets for the years back to 2010 could not be generated as there was no way to capture those firms which had ceased trading in the intervening years. However, by using data from TCR, it was possible to identify the cohort of firms that existed in 2010 and were still trading in 2013, referred to as 'survivor firms'. The performance of these firms was analysed to establish trend lines. This was judged to offer a best estimate, though it is likely to understate the rate of change as the impact of firm start-ups and closures are not captured and for most low carbon sectors business start-ups, and their economic impact, would be expected to exceed closures.

Trade data

The original aim was to collect detailed trade data directly from businesses that took part in the survey. However, a significant proportion of firms were unable to provide this; either for confidentiality reasons or because the data were not readily available. The responses gained from the survey were not sufficient to support a clear assessment of exports and imports across the whole of the low carbon economy.

A second approach was to use secondary trade data published by ONS to estimate exports and imports. Unfortunately, the available data are not detailed enough to build a sufficiently accurate view of the low carbon sectors.

As both approaches were unable to provide robust estimates it was decided that the data could not be included in the report.

Strengths of the method

This section provides an assessment of the robustness of the estimates for the low carbon economy. This includes a view of the strengths and limitations of the methodology, as well as recommendations for potential improvements for future work.

Overall the data are considered robust, especially for a first iteration of this methodology. The key determinants of accuracy and reliability of the data are:

- The completeness of the underlying database of companies. A total of 11,500 business units were identified. Significant time and effort was applied to identifying potential low carbon candidates and then checking to confirm whether or not they met the strict inclusion criteria set out in the definition. This was done to in order to generate a dataset that accurately represented the actual population of firms and neither over or understated it. As this is the first time that this has been attempted, it is not possible to make any direct comparison. A review of proxy measures, e.g. GVA per employee suggests an appropriate level of scale (low carbon sits in the middle of the mid to high tech manufacturing sector[73]).
- In addition to the firms included in the database, a key determinant of accuracy is the data associated with these companies, e.g. sector, turnover, employment and GVA. While some of the data were gained from the survey (630), the balance were derived from IDBR and TCR. IDBR represents the official record of businesses in the UK and TCR is the largest and most established longitudinal dataset of firms in the country. These data set an outside envelope for the low carbon economy (the turnover of the low carbon economy could not be greater than the sum of the turnover of all the firms involved).
- The survey and its application were core to estimating the extent to which the firms were engaged in the low carbon economy. The survey of 630 firms collected over 1600 responses in terms of activity in the low carbon economy (many firms operate in more than one sector).

Thus the estimates are considered robust at the overall level of the low carbon economy. The degree of robustness will diminish as the degree of detail increases (survey sample sizes become smaller). Likewise, there may be some uncertainty in the disaggregation of related sectors, e.g. onshore and offshore wind. However, despite issues associated with the fine detail, the overall figures are considered accurate, reliable and repeatable. The open method allows for further refinement as and when the research is repeated in the future.

The key strengths of the methodology are as follows:

- It allows for a detailed, flexible definition of the low carbon economy and the sectors that constitute it to be developed and, importantly, deployed.
- It builds the analysis from the ground up and therefore the results can be traced back to the economic entities (i.e. firms) that drive them.
- The definitions can be moderated through time and the impact of such changes on the results can be identified and compared to other drivers of difference (e.g. business performance, business closures and so on).

[73] Low carbon's GVA/employee of £110,000 is less than pharmaceuticals (£260,000) and chemicals (£140,000) but above ICT and precision instruments (£60,000), machinery (£55,000), automotive (£52,000) and aerospace (£50,000). Industrial Strategy: UK Sectoral Analysis, BIS, 2012.

- The business dataset, now created, can be updated year on year to support a longitudinal analysis of the low carbon economy and to identify, monitor and – when employed alongside other data – evaluated.
- The methodology is transparent. As with all research which is delivered within a limited budget, there are improvements that could be made, but there are no 'black boxes' and readers of this report will understand very well how the results are derived.
- The methodology has been considered and supported by professional researchers and economists who understand very well the challenges of such as study. This gives the approach a study additional gravitas and, consequently, increases the confidence in results.
- The research method was reviewed and validated by an independent peer group comprising representatives from the ONS, Carbon Trust and Committee on Climate Change.

Limitations of the method and scope for improvement

The key limitations of the methodology are as follows:

- The population of business may understate the number of businesses that participate in the low carbon economy as it relies on businesses identifying themselves for them to be included. Some businesses, particularly small firms, may operate below this 'radar'.
- The survey response sample of 633 businesses is significant in its own right but, given the breadth of the low carbon economy, could be considered the minimum required to deliver a study of this type. An expansion of the survey would increase the reliability of data at the sector group and low carbon sector level. As has been noted earlier, there were concerns regarding the representativeness of the survey sample compared to the population.
- The study is currently cross-sectional in nature. It relies on a snapshot of activity taken in 2014. It is not possible to 'backcast' the dataset to 2010 because some businesses that were in existence then have since closed. The performance analysis therefore relies on analysis of firms that have existed across the 2010-2013 period inclusive. The assumption is therefore that the impact of new business starts and closures cancel each other out. Re-running the data gathering exercise – which in effect would mean maintaining the dataset and re-surveying on an annual basis – would overcome this limitation.

As we move forward, new approaches to carbon reduction – supported by new technologies, products and services – will be researched, designed and come to market. The evolution of the sector is one of a number of considerations that future work in this field must consider. Monitoring of the research and development environment would therefore be a worthwhile exercise to support repetitions of studies such as this, to ensure that definitions are kept up to date and the activities captured within the data are as relevant as possible.

In order to address one of the limitations identified above, a time series dataset can be built up through subsequent work in this area. Businesses are born, evolve and die and this churn needs to be tracked in the data. This would allow the research to evolve from being 'cross sectional' to 'longitudinal'.

During the course of the study there have been calls for sector level data to be disaggregated to allow more detailed study. Examples include breaking down the sector covering energy generation from waste and biomass into three constituent parts: waste, biomass and landfill gas. This was not possible during the course of the study as the survey work was designed to capture data only down to the level of sector. A more bespoke analysis may provide additional insight into these breakdowns.

10.4 Appendix IV - The sectors in more detail

Onshore wind

- Development and consulting: forestry, logging and landscape services; meteorological surveys; environmental surveys; development services including: resource analysis and modelling; grid interface design; test facilities; and project management; scheme design and development: design; civil engineering; electrical design; and site modifications; and consulting.
- Turbine design and manufacture: turbine assembly and supply.
- Construction work including civil engineering works and foundations.
- Substation design and assembly.
- Turbine installation commissioning: delivery; erection; electrical installation and commissioning and technical testing and analysis.
- Grid connections: engineering and technical analysis and consulting.
- Operation and maintenance of the wind farm equipment, e.g. turbines, cables and substations.

Excluded:

- On-going operations and maintenance of distribution assets, e.g. grid.

Offshore wind

- Development and consulting: meteorological surveys; environmental surveys; seabed surveys; development services including: resource analysis and modelling; grid interface design; test facilities; and project management; scheme design and development: design; civil engineering; electrical design; and consulting.
- Turbine design and manufacture: turbine assembly and supply.
- Electrical equipment design and manufacture including: offshore substations and subsea cables.
- Installation commissioning: delivery including ports and supply vessels; erection, including: jackups and foundation manufacture and installation; electrical installation and commissioning: including installation of cables; substations; and technical testing and analysis.
- Grid connections: engineering and technical analysis and consulting.
- Maintenance.

Excluded:

- On-going operations and maintenance of distribution assets, e.g. grid.

Nuclear power

- Development and consultancy, including: concept design; project technical support; permitting; site licencing; design authority; programme management; safety course development; optioneering and risk analysis.
- Civil engineering and construction of superstructure and containment building. Construction of ancillary works, e.g. earth works, roads, drainage are excluded.
- Manufacture and supply of plant and equipment, including: reactor; boilers; turbines and generators. All other equipment excluded on the basis that it may not be nuclear specific.
- Installation and commissioning of plant and equipment (mainly class 1-3).
- Fuel cycle, including: enrichment; fabrication; reprocessing and research and development.
- Operations – power station operations management only.
- Waste and decommissioning, including decontamination and decommissioning.

The survey included some elements defined as supply chain due to the multiple reactor types e.g. PWR and BWR; inability to disaggregate activities within companies and complex ownership and operating arrangements, e.g. PBOs, SLCs and joint venture partners.

Hydroelectric energy

Large systems

- Development and consulting including project development and design.
- Technical consulting including geology, meteorology and ecology.
- Construction and engineering. Civil works excluded on the basis that these are generic and not low carbon specific.
- Operations and maintenance – where this is a primary, rather than secondary, activity.

Small systems

- Development and consulting.
- Low head turbine manufacture
- Installation and commissioning.

Small systems – modernisation and optimisation

- Control systems update
- Equipment design and manufacture: diversion weir; canal; penstock/ pipeline; turbine; power transfer; powerhouse; grid connection and maintenance.
- Installation and commissioning.

Marine

This was originally arranged into two separate sectors but merged for the survey work as it was so small.

Wave and tidal stream

- Development and consulting including: consulting; engineering services; civil engineering; electrical engineering; grid connections; consultation; site modifications; consenting and regulatory/legal.
- Turbine and generator manufacture. Platform and frames excluded as part of the supply chain.
- Electrical equipment manufacture including substation.
- Installation and engineering, including: material delivery; turbine installation and commissioning; and electrical installation and commissioning.
- Grid connections.
- Maintenance and operations. Operations only, maintenance and environmental monitoring excluded as supply chain.

Marine

Tidal range

- Development and consulting, including: design and engineering; grid connection and consulting.
- Construction, including: vessels for dredging, caisson installation, embankment construction; civils work.
- Assembly of tidal range systems. Manufacture of componentry excluded on the basis of being part of the supply chain.
- Grid connection: engineering, technical analysis and consulting.
- Installation and commissioning: equipment installation; commissioning and testing.
- Operations and maintenance: power generation only. Plant maintenance, dredging and environmental monitoring excluded as supply chain.

Solar PV

- Design and engineering, including: research and development; solar hybrid PVT; solar PV.
- Manufacture of PV equipment: PV panel and PVT systems.
- Specification, installation and commissioning.

Carbon capture and storage

Covers both application to power generation and industrial process plants.

- Research and development including: post combustion; pre-combustion; oxyfuel capture; CO2 compression and air separation.
- Project development, including: regulation; testing; feasibility; legal; environmental, planning, GHG accounting and engineering.
- Project finance.
- Design and manufacture of capture equipment.
- Installation and commissioning.
- Operations and maintenance, including technical monitoring and testing.
- Transport, including pipelines, trunk lines, and source to sink pipelines as well as transport by ship.
- Storage of CO2 offshore.
- Use in enhanced hydrocarbon recovery.

Biomass equipment

Covers equipment produced for both domestic and non-domestic use and the generation of power and heat (separately or as CHP).

- Development and consulting for biomass boilers and related equipment.
- Design and manufacture of boilers and turbines, including: compression ignition for synthetic diesel; turbines for electricity generation and co-generation; spark ignition engines; steam boilers for steam conversion; steam turbines for co-generation; gas turbines for co-generation; boilers for direct combustion to heat and fuel cells to convert methane/methanol to heat.
- Manufacture and supply of ancillary equipment for fuel handling.
- Construction works.
- Installation and commissioning: combustion appliance and fuel handling.

Excluded:

- Production and supply of biomass fuel, which is included in alternative fuels.

Geothermal heat (deep)

- System design and specification, including: geotechnical feasibility work; engineering design; site investigation and geotechnical consulting.
- Design and manufacture of equipment including: pipework, pumps and heat exchangers.
- Operations and maintenance, performance monitoring only.

Heat pumps

- Design and consultancy of systems: non-domestic and domestic.
- Manufacture and supply of heat pumps: air to air; air to water; water to air and water to water.
- Installation and commissioning: air source, ground source and water source.
- Manufacture of ground and water loop equipment, e.g. pipes and pumps excluded as supply chain.

Solar thermal

- Design and engineering including: solar thermal; solar PVT, concentrated solar power; research and development.
- Manufacture of solar equipment, including: solar thermal, PVT and ancillary equipment.
- Specification, installation and commissioning.

Heat networks

- Development and consultancy, including: heat generation; heat distribution; legal and regulatory.
- Manufacture and supply of specialist heat distribution equipment (heat generation elsewhere).
- Installation and commissioning of heat distribution equipment.
- Operations and maintenance, excluding generic maintenance.

Generation of energy from waste and biomass

- Project development including: financing; planning; permitting and health/risk assessments.
- Design and manufacture of electricity from waste equipment, including: combination electricity/heat systems; steam generation, turbines and heat recovery systems. Does not include biomass boilers or turbines as these are in biomass equipment.
- Civil engineering.
- Equipment installation and commissioning, including: fuel handling; steam generation; electricity generation; and heat recovery systems.
- Design, manufacture and supply of pre-treatment equipment.
- Operation of facilities that generate energy (heat and/or electricity) from waste and biomass. Thus it includes electricity from waste plants, e.g. Cory Environmental's Belevedere plant in Bexley and biomass fired stations such as Veolia Energy-Dalkia's Chilton plant in Northumberland.

Excluded activities include:

- Fuel supply (alternative fuels), generic power generation and generic emissions abatement.
- In-house facilities that are being used to replace purchase of energy from the grid or which make use of a combustible waste/by-product from a manufacturing process. This exclusion is based on the practical difficulties of identifying and capturing such plants with any degree of consistency or completeness. Thus it is likely that the value of the sector has been under-reported.

Energy-efficient lighting

- R&D into energy efficient lamps.
- Manufacture of LED lamps and luminaires, including: dimmable and non-dimmable lamps.
- Manufacture of compact fluorescent lamps and luminaires.

- Design of low energy lighting arrangements.
- Distribution of low energy lamps and luminaires

Excluded:

- Installation of LED and CFL lighting. Natural lighting included in sustainable architecture and buildings.

Insulation

- Development and consulting, including survey and specification.
- Manufacture of insulation, including: external wall; internal wall; floor; roof; loft; cavity wall; insulated concrete and arctic wall.
- Installation by specialist providers.

Excluded:

- Installation of insulation as part of general construction and chemicals used in insulation manufacture as they are part of the supply chain.

Energy-efficient windows and doors

- Manufacture of doors, including: fibre glass doors; composite doors; glass doors; insulated steel doors; and hardwood doors.
- Manufacture and assembly of windows.

Excluded:

- Manufacture of components and installation of windows and doors, as they are part of the supply chain.

Heat recovery and ventilation

- Design and manufacture of heat recovery and ventilation equipment including heat exchangers.
- Installation and commissioning of heat recovery and passive flue equipment.

Excluded:

- Manufacture and installation of air conditioning (unless reversible cycle – heat pump) and heating systems not included as non-low carbon.

Sustainable architecture and buildings

- Design activities involving architects and engineers.
- Construction including: energy efficient products, specialist materials and systems such as rainwater harvesting.
- Innovation and development work covering improved standards.
- Demolition and recovery of materials.

Excluded:

- General construction and ancillary activities such as planning and disposal of site waste as non-low carbon.

Energy controls and control systems

- Design and manufacture of energy management systems.
- Design and production of specialist software.
- Design and manufacture of smart meters, communications hubs, displays and control systems.

Excluded:

- Manufacture of components, design and manufacture of condensation controls as non-low carbon.

Low carbon advisory services

- General project design and delivery support, including: business case development; development and review of technical specifications; options appraisal; developing delivery structures; finance and funding mechanisms.
- Consulting, including: technical consulting; regulatory advice; advice on support services and specialist studies.
- It should be noted that some large consultancies have been included within other low carbon sectors, rather than in advisory services, due to the prominent role they play, e.g. in nuclear.

Excluded:

• Teaching and training and public sector management.
Low carbon finance • Advice and guidance to secure capital to support innovation and development of new low carbon technologies. • Advice and guidance on raising finance for low carbon projects (procurement). • Provision of finance specifically for low carbon projects. Excluded: • Generic guidance and supply of finance.
Recycling - recovery and reprocessing of materials from waste • Collection and sorting of materials for reprocessing. • Activities involved in the reprocessing of materials such as plastics and paper. • Re-engineering and preparation for re-use of used products. • Sale of reprocessed materials (coverage may be limited if handled by 3rd parties, i.e. not by the reprocessors). Excluded: Collection and processing of materials sent to landfill.
Alternative fuels • Production of biofuels including: biodiesel, bioethanol, biomethanol, biogas and hydrogen, from both virgin and reprocessed matter. Excludes production of pure vegetable and plant oils as well as production and collection of feedstocks, unless specifically for fuel use. • Production and processing of biomass for generation of electricity and heat. • Design and manufacture of equipment to produce biofuels. • Research and development. • Certification of fuels.
Low emission vehicles • R&D into low emission vehicles. • Manufacture of LEVs: hydrogen fuel cell and plug-in vehicles (serial electric/combustion systems). • Manufacture of batteries for use in vehicles. • Battery maintenance. • Fuelling of battery and hydrogen vehicles. Excluded: • Design and manufacture of motor vehicles using combustion engines only, generic vehicle maintenance, retailing and general servicing of vehicles.

10.5 Appendix V – Trends Central Resource (TCR)

Trends Central Resource (TCR) is a unique business dataset owned by Trends Business Research Ltd (TBR). It is one of the most extensive bodies of information on UK enterprise. It was developed by TBR following original research undertaken over 25 years ago to demonstrate the important job creation role of small firms. It contains data on nearly 3 million live, active and trading firms and organisations in the UK, together with historical information on a further 5 million organisations going back to the 1970s. The key sources of data are Companies House and Dun and Bradstreet.

It contains, for each firm on the database, details on employment, turnover and GVA[74] as well as other attributes such as; business activity, ownership structures, executives, type of entity, start-up year and a host of other descriptors. Information is held as a seamless time series going back to 2000[75]. This makes data access and retrieval an extremely efficient process. TCR represents the whole UK population. Unlike other data sources it includes firms below the VAT threshold, branch sites, and the self-employed. As such TCR is a fuller, more complete picture of a local economy or market.

One of the core benefits of TCR's granular nature is the ability to go below Standard Industrial Classification (SIC) level. This ability is made possible through the business activity description associated with each business record. TBR can perform keyword searches on these descriptions to identify and analyse niche activities that can't usually be understood through official datasets. Using this methodology the composition of any given local economy or sector can therefore be fully understood, no matter how localised or niche, and compared with any area in the UK.

[74] GVA is generated by summing: profit before tax, employment costs, and amortisation and depreciation. Data on these metrics is contained within TCR.
[75] Some data is available going back to the 1970s. However, consistent GVA data are available from 2000.

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