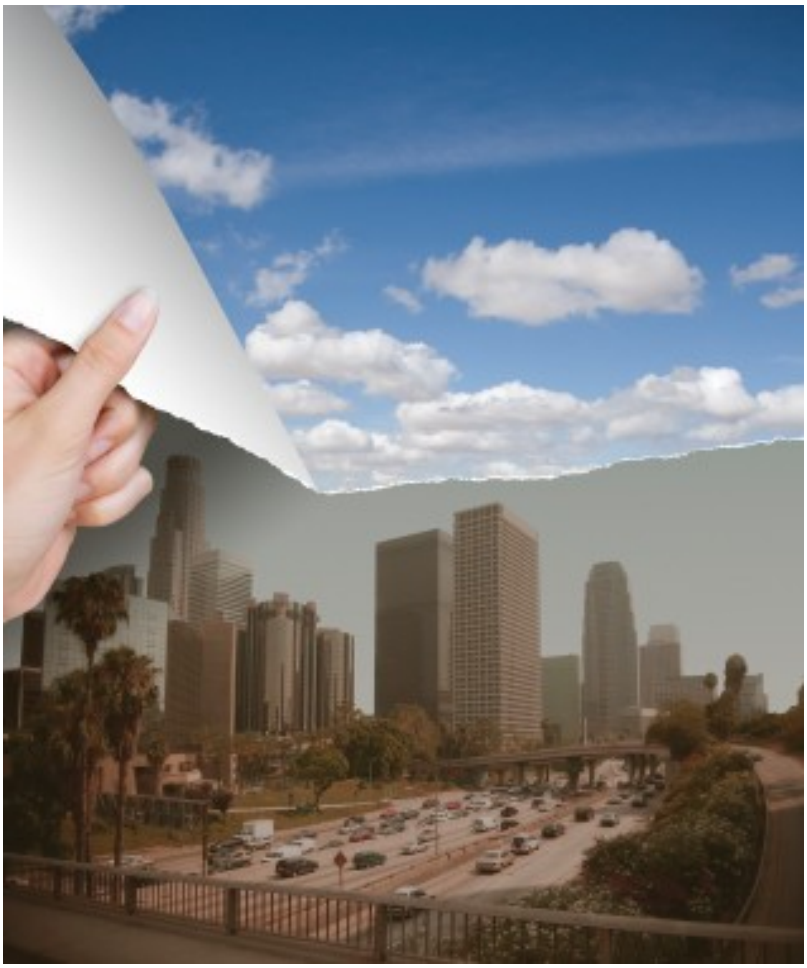

Developing Scotland's low carbon built environment - Phase 1 summary report

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Contents

1 Background 1
1.1 Scottish industry and policy drivers 1
2 Introduction 4
2.1 Aims and objectives 4
2.2 Methodology 4
2.3 Reporting 5
3 Identifying the nature, scale and potential of the LCBE 7
3.1 Overview 7
3.2 Defining the Low Carbon Built Environment (LCBE) 7
4 Qualify Scotland's strengths in the LCBE sector 25
4.1 Market attractiveness 25
4.2 Supply chain 26
4.3 R&D capability 27
4.4 Promoting the use of homegrown Scottish timber 27
4.5 Demand side management 27
4.6 Renewable heat 27
5 Identifying key linkages between LCBE and SE priorities 29
5.1 Digital markets and enabling technologies 29
5.2 Energy 29
5.3 Construction 29
5.4 Forestry 30
6 Identifying failures and opportunities to grow 31
6.1 Market failures 31
6.2 Opportunities within the LCBE sector 33
7 Conclusions 34
8 References 35
Appendix 1 – Company's House SIC code data
Appendix 2 – RAE classifications for Scottish Universities

1 Background

The Low Carbon and Environmental Goods and Services (LCEGS) Industry has emerged as an area of potential growth in Scotland. The LCEGS industry sector is being driven by changes in Government climate change policy and by the production of products and services which can meet the low carbon 'challenge'. According to a recent UK Government report, UK is currently ranked 6th [1] in the global LCEGS with UK services in a market valued at £106.5 billion (2007/2008), with the potential to grow by another £45billion over eight years (to 2014). The sales market value of LCEGS in Scotland in 2007/2008 was valued at £8.5billion, around 8% of UK market value. With market growth estimated to average 5.6% over the next six years (from 2009) this could see growth to £12 billion for Scotland's economy. Assuming the same growth rate, the number companies operating in these markets has potential to increase from 4,100 to 5,700 and employee numbers rise from 73,000 to 101,300.

However, these statistics are representative of Environmental Sector, Renewable Energy Sector and the emerging Low Carbon Sector. Elements of each of these sectors are not applicable for the purpose of this report, where the focus remains on the built environment. The key sectors within LCEGS industry which are relevant to this work are energy management and building technologies.

Scottish Enterprise (SE) teams have been evaluating the potential for investment in the low carbon built environment sector for Scotland. Initial research provided base case evidence that market opportunities could be realised in this sector. SE appointed BRE (Building Research Establishment Limited) to undertake a study to determine the economic potential for Scotland in this sector. Key outcome for the project was the identification of barriers and opportunities to enable SE to maximise Gross Value Added (GVA) for the Scottish economy.

The Low Carbon Built Environment (LCBE) could be defined over a wide range of products, technologies and infrastructure which contribute to the energy performance of buildings. For the purposes of this project, however, the LCBE sector is defined as the range of products and services which have the potential to reduce the carbon emissions from a building during its operational lifetime. This limits the products and technologies to be considered to those which contribute to the performance of the building in relation to its energy and water consumption.

1.1 Scottish industry and policy drivers

The low carbon industry in Scotland is growing at varying rates over the range of industry sectors. This is being driven by the recognition that all member states within the EU have a duty under the Energy Performance of Buildings Directive [2] to reduce the energy demand from the built environment. This Directive has led to documents and guidance being developed for use in Scotland. A selection of these documents are described in Table 1 and these act as the main drivers for Scotland's developing low carbon built environment industry.

The development of the LCBE in Scotland has been discussed for a number of years, both within the industry and at Government level. The industry is generally aware of the direction in which Scotland is heading with regard to its carbon reduction targets. However, how these targets are to be met is a little less

defined. The recently published Climate Change (Scotland) Bill (2009) [3], has indicated that the delivery mechanism for carbon reduction targets will be through Building Regulations. The next revision of the Regulations is Scotland is due in the latter part of 2010.

It is widely expected that the recommendations of the Sullivan Report [4] will be implemented within this revision. This is likely to include a 30% improvement in energy targets for domestic buildings (based on 2007 Standards) and 50% improvement in energy for non-domestic buildings. These targets present a significant challenge to the construction industry and the associated supply chain, and are likely to cause a step change in product development and specification.

As the future targets for carbon reduction within the built environment become more apparent, the industry in Scotland has been making tentative steps towards developing solutions to meet these targets. Activity in this area has been limited to a selection of organisations which have been developing innovative products which have the potential to reduce carbon emissions from buildings. These products and technologies have the potential to assist Scotland in meeting its carbon reduction targets.

The lack of demand from specifiers and clients for low carbon products is reflected somewhat by the current level of industry activity in Scotland in the low carbon sector. This demand is driven, primarily, by legislation and regulation which is not currently in place. Consequently, the industry in Scotland and across the UK [5], will have to go through some rapid changes as early as 2010 as new regulations come into force. This will present some challenges, but also significant opportunities for organisations within Scotland to position themselves ahead of their competitors on a national, international and global scale.

The challenges to the industry in meeting future targets within Scotland will be significant. Investment in the industry is, therefore, important and will be required to meet these challenges. This should be the focus for funding agencies in the coming years. Scotland has set some of the highest targets in the world regarding climate change [6] and carbon emissions reduction. Therefore, there are significant opportunities for Scottish companies to lead the way in developing and delivering solutions to meet these targets. Once Scotland has established the markets and supply chains for delivering against national targets, there will be additional opportunities to penetrate global markets.

Table 1. Drivers for developing Scotland's LCBE.

Energy Performance of Buildings Directive (2002)
The Energy Performance of Buildings Directive (EPBD) was approved on 16 December 2002 and brought into force on 4 January 2003. The principal objective of the Directive is to promote the improvement of the energy performance of buildings within the EU through cost-effective measures. There are four main aspects to the EPBD: 1) Establishment of a calculation methodology: Member States must implement a methodology for the calculation of the energy performance of buildings, taking account of all factors that influence energy use 2) Minimum energy performance requirements: there must be regulations that set minimum energy performance requirements for new buildings and for large existing buildings when they are refurbished 3) Energy performance certificates: there must be an energy performance certificate made available whenever buildings are constructed, sold or rented out 4) Inspections of boilers and air-conditioning: there must be regulations to require inspections of boilers and heating systems and inspection of air conditioning systems.
Sullivan Report (2007)
The Minister for Transport, Infrastructure and Climate Change, Stewart Stevenson, MSP, appointed a panel to advise on the development of a low carbon building standards strategy to increase energy efficiency and reduce carbon emissions. The panel has made 56 recommendations for the Scottish Government, the majority of which are within the remit of the Scottish Building Standards Division. The Scottish Government will have to consider the cost implications of the panel's recommendations, which include: • staged increases in energy standards in 2010 and 2013 to substantially reduce carbon emissions from new buildings; • the aim of net zero carbon emissions for space heating, hot water, lighting and ventilation within the next 10 years, if practical; • the ambition of total-life zero carbon buildings by 2030.
Climate Change (Scotland) Bill (2009)
On June 24, 2009 the Scottish Parliament passed the Climate Change (Scotland) Bill, which places Scotland at the forefront of global efforts in tackling climate change. The Bill will create a long-term framework that will: • Introduce a statutory target to reduce Scotland's greenhouse gas emissions by at least 80 per cent by 2050 • Establish an interim target of at least 42% emissions reductions by 2020, with a power for this to be varied based on expert advice from the UK Committee on Climate Change • Establish a framework of annual targets • Include emissions from international aviation and international shipping. This framework will help to build a sustainable future for Scotland. It will contribute to the country's sustainable economic growth by moving the public and private sectors towards a low carbon economy. The Bill has also identified areas where specific targets should be determined including: • Promotion of energy efficiency, including plans on how Building Regulations will help to meet future targets • Promotion of renewable heat, including set targets for a percentage of heat produced by renewable sources • Setting Regulations to promote energy efficiency in domestic and non-domestic buildings.

2 Introduction

2.1 Aims and objectives

SE has identified the LCBE as a potential growth area which could impact positively on Scotland's economy, from exposure to both national and international market opportunities. Following initial research by SE it was concluded that although the construction sector is mature, there was insufficient information on the strengths and weakness in developing low carbon building practice. The aim of this work is, therefore, to identify the nature and scale of this emerging sector in Scotland. The first phase of the project has a number of objectives as follows:

Phase 1

- quantify and qualify the value, nature and scale of the LCBE to the Scottish economy

- define the current size of the sector and LCBE value chains including, key supply chain organisations, customers and influencers

- qualify and validate the strengths that Scotland has in the LCBE sector, e.g. market attractiveness, R&D capability, supply chain, etc

- identify areas in which Scotland has realistic potential to compete globally

- identify key linkages within the LCBE sector and SE priority industry strategy

- identify the key market failures and propose opportunities to grow the LCBE sector.

This report will summarise the findings from the work undertaken in phase 1 of the project.

2.2 Methodology

The research focussed on determining activity in Scotland that contributed to, the developing LCBE. Most of BRE's current work streams are either directly or indirectly related to the LCBE and, as such, BRE were able to identify and liaise with individuals and organisations who could contribute positively to this work.

In order to evaluate this industry sector and related activities, the LCBE was divided in sub-sectors as follows:

- Building envelope
- Technologies
- Professional services
- Research and development.

The categorisation of these sub-sectors was informed by industry SIC-codes and allowed statistical information to be presented effectively. These sub-sectors were also investigated with regard to their particular characteristics, strengths and weaknesses in the developing low carbon industry.

The research carried out during this work involved a number of activities as follows:

- Consultation with the industry through a questionnaire, workshop events, one-to-one interviews with personal contacts
- Review of recent industry statistical reports such as the BERR report [1], ITI [7], British Wind Energy Association [8], Scottish Renewables Forum [9], Scottish Construction Industry Plan [10], BRE documents and others
- Dialogue with organisations within the industry who are pushing forward low carbon solutions within their industry sectors.

This allowed much of the current thinking on the LCBE to be captured and reported. BRE's contacts were particularly important as industry activity in this area is often not documented effectively or widely. This is, in part, due to the relative immaturity of the industry sector.

Detailed feedback was also obtained through the online questionnaire, which attracted more then 200 responses from Scottish businesses. The questionnaire was targeted at organisations who are active in Scotland and whose business is to some degree engaged in low carbon products and/or services. Focusing on this group provided an insight into the experiences of developing, supplying and procuring these products and/or services. This was specifically addressed by asking questions on the following aspects:

- Organisations' low carbon products and services currently in the market place
- Difficulties and rewards of engaging in this business area
- Awareness and take up of potential funding streams
- The identification of Scotland's inherent weaknesses and strengths in enabling business in this area.

The findings from this questionnaire were used to inform the findings of this work and provided valuable insight into the LCBE in Scotland. A summary report of the questionnaire analysis has been provided to Scottish Enterprise as an addendum to this report.

2.3 Reporting

The purpose of this document is to report on the research findings for the Phase 1 objectives as described in Section 2.1. The report gives an indication of the size of the LCBE sector in Scotland, based on recent statistics and the industry consultation carried out by BRE.

Section 3 of the report goes into detail on the each of the LCBE sub-sectors (building envelope, technologies, professional services, and R&D). This is presented in tabular form and covers topics such as:

- Sector overview
- Market trends

- Company examples
- Barriers to development
- Opportunities – domestic and global
- Recommendations and conclusions.

From the information collected by BRE, it is clear that a number of organisations are operating across the LCBE sector. Mapping the supply chain and identifying key organisations is also reported in Section 3 of this report. This allowed Scotland's strengths in the LCBE to be identified, together with the country's potential to compete within the UK and beyond. These findings are reported in Section 4.

Section 5 of the report identifies linkages from the emerging LCBE and SE priority areas. This is key to highlighting possible opportunities to grow the LCBE sector, which is described in Section 6.

3 Identifying the nature, scale and potential of the LCBE

Objective: Quantify and qualify the nature and scale of the LCBE to the Scottish economy

3.1 Overview

The nature and scale of the construction industry is wide ranging and has direct links to other key industries such as the financial, legal and energy sectors. The LCBE sector in Scotland is emerging and some of the associated products and technologies are at varying stages of development and utilisation.

Within the built environment, there exists huge potential for economic growth within Scotland. Government targets for renewable energy [5], as well as proposed changes to Building Standards as described in the Sullivan Report [6], will ensure that the industry will have to adapt, expand, and innovate to meet these challenges. The timescale associated with changes in Government policy, and Building Standards in particular, is not measured in years, but months. For example, the Sullivan Report suggests that 2010 Standards for energy should see a 30% improvement on 2007 Standards. This jumps to 60% by 2013 which will require a significant improvement in building fabric, materials, technologies and construction process.

Industry supply chains and products will have to adapt to meet these challenges. In some cases, many new products and technologies are emerging. However, this activity is fragmented and is being driven forward on a company-by-company basis, often without any central support mechanism or funding. Other parts of the industry are not looking as far ahead and are trying to address current targets in challenging economic conditions.

What is clear, however, is a need for a centralised and structured support mechanism and strategy that can support the industry and position Scotland as leaders in an emerging LCBE. The targets for energy saving will continue to increase and the industry needs to position itself to deliver against these targets in an efficient and productive manner.

Examples of the expertise and innovation that exists in Scotland will be described in the following Sections of this report.

3.2 Defining the Low Carbon Built Environment (LCBE)

Carbon emissions from buildings are affected by a number of factors including the building fabric, energy provision and the external environment. For the purposes of this project, SE and BRE have provided a definition of the low carbon built environment as follows:

“The LCBE can be defined as the range of products and services which have the potential to reduce the carbon emissions from a building during its operational lifetime”.

The LCBE is, therefore, directly related to organisations and activities in the following areas:

- research, testing and manufacture of products and technologies

- professional services in the design and specification of buildings and associated products
- construction site activities and installation of products and technologies

In order to quantify and qualify the nature and scale of the LCBE, the sector was divided in to four sub-sectors. These sub-sectors cut across the activities described above and are listed as follows:

1. building envelope
2. technologies
3. professional services
4. research and development activities.

Organisations within these sub-sector headings were selected through their influence on the LCBE and their categorisation through industry SIC codes. This allowed information on the scale of active Scottish companies to be identified using data sources from Companies House. BRE has obtained company information (size, turnover, employees, etc) on the organisations used in this analysis and has verified the GVA calculation procedure with Scottish Enterprise. This information is summarised in Table 2.

It should be noted that the information given in Table 2 is representative of the activity of organisations who are operating in any of the four areas described above. However, it is more difficult to determine how much of this activity is directly related to the design, development and construction of low carbon buildings and associated products. BRE has recently conducted a survey of more than two hundred Scottish companies which indicated that up to 40% of respondents activity was directly related to the LCBE sector.

To qualify each of the of the LCBE areas described in Table 2, the particular trends, barriers and opportunities for their development were assessed. The findings from this work item are described in the following sections of this report.

Table 2. Scottish industry activity relating to the LCBE.

LCBE area	Number of organisations	GVA per employee (£)
Building envelope	8645	55,291
Technologies	2270	34,069
Professional services	2270	45,445
Research and development	1004	74,791

The information in Table 2 has been derived through detailed analysis of SIC code information for industry sectors which contribute to the low carbon built environment. Through the use of data from Company's House, BRE identified more than 14,000 businesses in Scotland who operated in the four LCBE areas listed in Table 2. A further breakdown of the number of companies identified by SIC code is given in

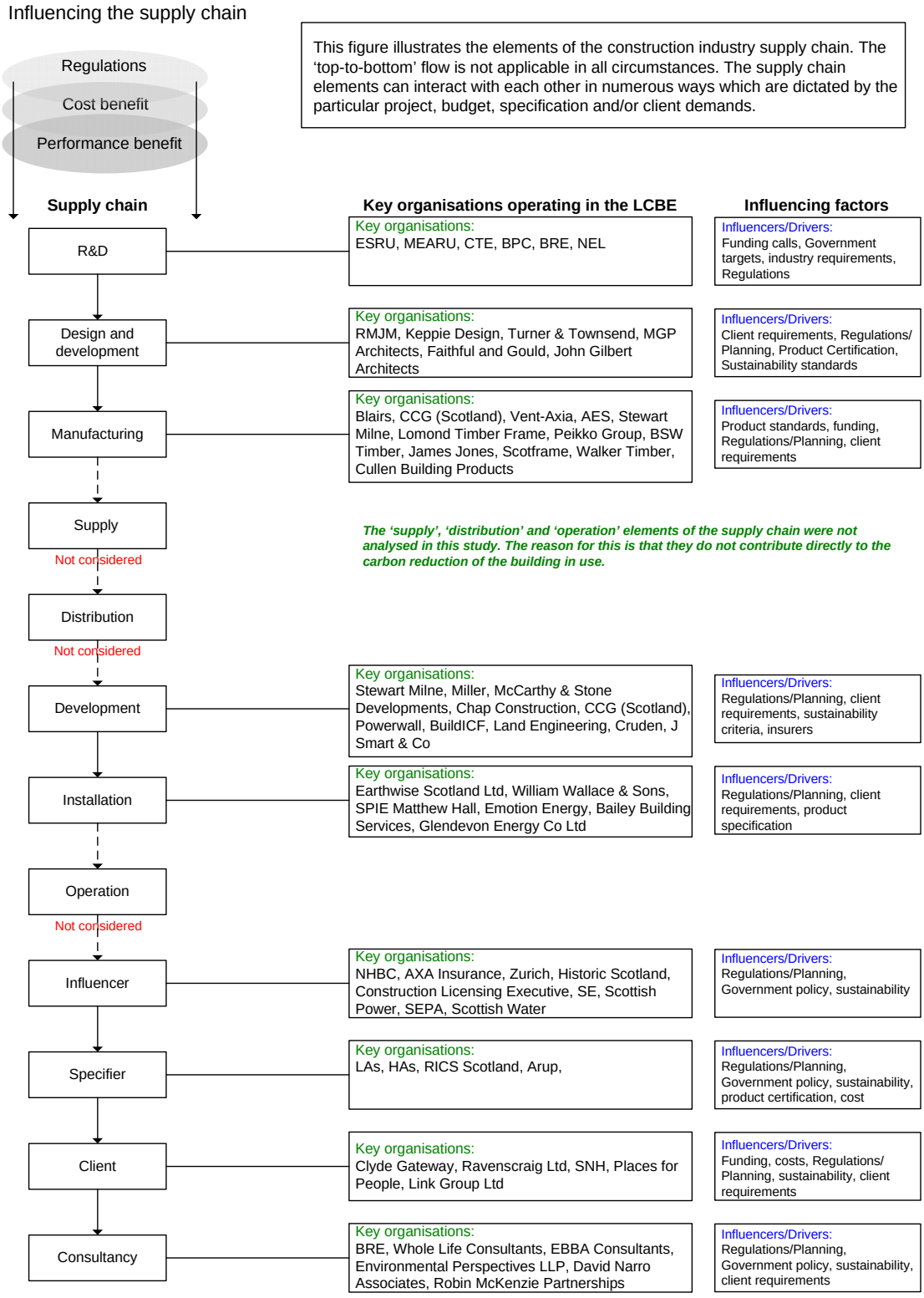
Appendix 1. A sample of these businesses was taken to inform the GVA calculation, which was carried out using the following equation:

GVA = Operational Profit + Employee Costs + Depreciation + Amortisation

The company data used in GVA calculation procedure includes information relating to company name, size, and turnover. The information is presented within a spreadsheet and is not provided in this written document. The spreadsheet also contains company information relating to address (geographical location).This information has been provide to Scottish Enterprise by BRE is available on request.

During the industry consultation process, BRE also developed a supply chain model. This described the key elements of the supply chain, active and key organisations in the LCBE sectors and their influencers. This supply chain model is shown in Figure 1.

Figure 1. Supply chain map including key supply chain organisations, customers and influencers.



LCBE sector area – Building envelope	
Definition	The building envelope is defined as the materials and products which make up the internal and external elements of a building e.g. walls, floors, roofs, windows. In the LCBE this could include offsite manufactured wall systems, innovative insulation products, phase change materials, etc.
Sector overview	Organisations within the building envelope sector will continue to grow their activities as energy performance requirements are increased. An example of this is air tightness requirements of building regulations and reduced carbon emissions driving forward product performance and efficiency (as recently announced in Scottish Building Standards Section 6 Energy consultation). In domestic buildings, Scottish new build construction is traditionally timber frame as opposed to England and Wales where brick and block is the preferred form of construction. The majority of timber frame is imported from Europe, as Scottish timber is often perceived to be of insufficient structural quality. However, with increased use of closed panel systems such as SIPs (Structured Insulated Panels), massive timber structures and related research, there is the potential for Scottish timber to be utilised on a larger scale.
Market trends	The construction industry will look to product manufacturers and contractors that produce the materials and components for the building envelope, to provide the biggest impact on the energy performance of the building. BRE's consultation with the industry has identified that the focus should be on 'build tight, insulate right, and assess need for renewables'. The regulatory framework is signalling a move to low carbon development from 2010 [4]. The early adopters in the market are keen to ensure their products and services are ready to deliver against these low carbon targets. Respondents to the questionnaire stated that 50% of their business was involved in low carbon products and services, although currently, there is no regulatory framework in place that requires them to do so. With policy signalling step changes to low and zero carbon development all organisations involved in construction will have to expand their current practices. The method of calculating the energy performance of buildings has changed in recent years from an elemental method (calculation of U-Values for walls, floors, roofs, etc) to a whole building calculation procedure which determines the CO_2 kg/m^2 per year. There are minimum U-Value levels for the elements, however current calculation procedures have identified the combination of these elements, utilities and technologies within a building as being the preferred method of assessment. This new method of calculating building energy performance is driving collaborative working practices between supply chain members. Although market activity in the production of materials, products and technologies that can be integrated into low carbon buildings is difficult to determine, statistical information is available on manufacturing and construction. One possibility is that there will be shift to named elements such as 'low carbon wall systems' or 'low carbon floor systems' ,although not being developed by the industry specifically, such products will be developed as a result of this legislation.
Scotland's strengths – current examples	Examples of building envelope sub-sectors which are operating in the LCBE are described below. The **Scottish timber** industry has been supported in recent years by research activities which highlight the potential uses for homegrown timber. The use of homegrown timber for structural framing, cladding, and manufactured structural panels has benefits when assessing the sustainability of the material and its application. It also has obvious benefits for the national economy and associated supply chains. There are a number of Scottish companies who are utilising Scottish timber products such as BSW Timber, Scotframe, Blairs, and James Jones. BSW Timber has sawmilling sites in the north of Scotland. They have also developed a panelised walling system that can be constructed with a traditional timber kit, and utilising Scottish timber. This system is erected on-

	site and using local labour where appropriate. **Offsite manufacture** and new construction processes are being developed by Scottish companies to address the energy and airtightness performance levels required by low carbon buildings. Stewart Milne are developing new systems and approaches to meet future energy targets. They are currently looking at a 'fabric 1st' approach which will maximise the benefits and carbon savings from the building envelope. This approach is building on their experiences on the BRE Innovation Park and will be piloted in demonstration developments in the coming months. Powerwall are based in Lanarkshire and design and manufacture volumetric building systems. They have developed an offsite manufacturing system which is flexible in its layout and can accommodate various building types and uses. Powerwall have recently secured contracts to export hundreds of units to Dubai and surrounding areas. The development of new **materials** through recycling and re-engineering can contribute significantly to the performance of low carbon buildings. An example of this is Kraft Architecture who have prototyped an innovative insulation material which is manufactured from waste material. Manufacturing capability for the product is not currently available in Scotland, however there is potential to create a facility and associated supply chain in the future. Build ICF are system supplier and developer, based in Lockerbie, who provide an insulated concrete formwork system. They are currently in negotiations in Brazil and Angola to export their residential build systems for large-scale developments. BuildICF are also looking to engage with the waste packaging industry and to set up a manufacturing base in Scotland.
Barriers to development	During BRE's consultation with the industry, the main barrier to development stated by organisations was affordability. The costs to undertake R&D to provide carbon emission data on products is significant especially as there is a risk that the product will not perform to the required energy levels as designed. The cost to undertake this testing and validation cannot be recouped on production of a rating that is not what the product manufacturer wanted. The following are other areas where barriers stated were common: • Affordability • Regulatory and legislative issues • A lack of customer (both client and public) demand for low carbon products and technologies as a result of lack of awareness about whole life benefits • The ability to secure insurance and warranties for completed buildings from organisations such as NHBC and Zurich. The issues identified here are also reflected in a recent UK Government study which has looked at strategies to develop the low carbon industry [5].
Opportunities for development – Domestic market	The domestic market for low carbon building products will primarily be driven by legislation (a common thread from responses to the online questionnaire). The policy signalling from Building Standards Division is that carbon emissions are to be reduced by 30% over current regulations by 2010, elsewhere in the United Kingdom it is to be a 25% reduction. This presents Scottish companies with the opportunity to lead in the development of products that meet the emissions target. There will then be opportunities to present industry developments to early adopters elsewhere in UK. This will require investment support to encourage innovation across the supply chain to deliver low carbon solutions to the market. A recommendation from Edinburgh Napier University was development of an 'off the shelf' dwelling specification that meets future energy targets. This may enable smaller companies to deliver on this agenda without incurring upfront R&D costs for their own products. The increase in environmentally certified buildings requires data on the environmental profile of products from 'extraction' to 'end of life' use. This is effectively providing data on the capital carbon associated with a building's construction. The Carbon Trust is

	currently lobbying for such data to be made available for public sector contracts. In addition to this, the 'Green Guide to Specification' is used by architects and engineers when specifying products for projects. This document contains information on the environmental rating of products from, 'A' being products required to secure highest environmental rating, to poorer performers at a 'C' rating. Companies with this level of data on products are more likely to secure projects as the requirement from clients' increases. There is an opportunity for organisations to work with testing and validation centres in providing support for companies who are looking to obtain environmental product information. It is generally a costly process, especially at the early stages of product development, and this can stifle growth and price some SME's out of the market. Upgrading the existing building stock is the focus of Government initiatives such as the 'Retrofit' funding call from Technology Strategy Board and 'Energy Efficiency Design' call from Energy Saving Trust. The existing property market is also an area for policy development within the Scottish Climate Change Bill. This market is primed for organisations working with products such as insulation, doors and windows to aid the reduction in carbon emissions associated with heat loss of new buildings. Product development to increase the carbon savings will be a challenge for organisations already faced with a downturn in new build work. There is an opportunity for Scottish Enterprise to broker relations between SME's, clients, research centres and funding bodies.
Opportunities for development - Global	During BRE's consultation with the industry it was highlighted that the Scottish timber harvest is set to double over the next 10 years. It is unlikely, however, that Scotland would have success in exporting the harvested timber product as countries such as Canada and Russia have much larger woodland industries. There is the potential, however, to increase the market for Scottish timber products across the rest of the UK. Scottish timber is often viewed as not of sufficient quality for construction under Scottish regulations. This perception is being challenged by recent research activities and shifts in construction practices. The development of the Structured Insulated Panel System (SIP) presents an opportunity for offsite manufacture using Scottish timber. This opportunity is present in both the domestic and global markets. Such products could be licensed for export to foreign markets allowing product IP and manufacture to be retained within Scotland. A recent Financial Times supplement highlighted opportunities in Poland as this area was not affected by the economic downturn. Rapid development is required in this area which may provide opportunities for the development of offsite systems that could be exported. It is not perceived that a sufficient regulation barrier is in place to deter import of Scottish timber, as demonstrated in the BERR [1] Heat maps. The United Arab Emirates, and in particular Abu Dhabi, is constructing a zero carbon development in which there is a requirement to provide data on environmental performance of products. The UK has already developed methodologies to undertake production of this data, however as stated earlier, it is expensive for organisations to progress, and with intervention from funding agencies this could be overcome.
Recommendations	Recommendations for the sector area include: • Encourage closer collaboration of testing and validation organisations with product manufacturers. This will help to provide environmental and low carbon data on products for use in both domestic and global markets. • Investigate the possibility of design specification for domestic buildings that meets future energy targets. The design should be suitable as an 'off the shelf' specification developed using offsite manufacture techniques for mass market roll out. • Provision of brokering facility for organisations working in the refurbishment sector to encourage collaborative bids for funding calls. This will stimulate innovation in retrofit of existing stock to reduce carbon emissions as signalled in Scottish Climate

	Change Bill. • Encourage collaboration between forestry sector and construction sector in use of Scottish timber. This could include developing innovative panel systems for offsite manufacture that can be used in domestic market as well as being exported. • Provision of awareness raising activity and education for trades as low carbon legislation approaches.
Conclusions	The building envelope is critical in ensuring minimum energy rating as the prophecy is to 'build right, insulate tight, and assess the need for renewables'. This sector will undertake the biggest transformation of all the elements considered in this work as standard products and processes have to adapt. However, this brings opportunities for collaborations with academia and other members of supply chain with potential to open up new markets in Scotland, the rest of UK and elsewhere in Europe. From feedback received during the industry consultation, sufficient investment mechanism must exist to enable this sector to grow.

LCBE sector area – Technologies and renewable energy sources	
Definition	The renewable energy sub-sector includes all products and services that contribute to the supply, management and use of water and energy within a building. In the LCBE this would primarily be related to renewable energy devices such as wind, solar, geothermal, hydro, CHP, etc. The technologies sub-sector includes products which contribute to the supply, distribution and management of energy within a building. The renewable energy and technologies sub-sectors have been combined in this study as they are commonly integrated to manage the energy supply and utilisation within a building.
Sector overview	**Technologies** Technologies associated with heating, ventilation and lighting equipment have evolved over a number of years and are relatively established and recognised by the industry. The introduction of internet-enabled technologies and smart metering has provided opportunities for wider collaboration with electronics industry, panel systems and academia. Innovations in this sector have provided opportunities for carbon savings from buildings by providing information on energy management and usage. There is, however, significant scope to expand the application of these technologies which may be affected by customer demand and legislative obstacles. **Renewable energy** Energy Policy is tackling the issue of climate change by reducing emissions whilst ensuring the energy supply remains secure. As well as strongly supporting international action to address climate change at EU, G8 and UN level, Scottish Government has set the ambitious target of reducing Scotland's carbon emissions by 80% by 2050 [3]. The development and establishment of technologies within the LCBE sector is continuously evolving. Consequently, the contribution they make to the energy use in a building is variable and often specific to an individual application. The breakdown of energy use by sector in Scotland is 45% heat, 29% transport, and 26% electricity. The energy use from renewable energy technologies in Scotland was estimated in 2006 to be 16% of gross electricity consumption, 1% of heat and 0.44% biofuels for transport. Overall, Scottish energy consumption from renewable technologies was 4.6% [11]. The Scottish Government target is for renewable technologies to provide 50% of gross electricity consumption. Within this figure, renewable heat would have to increase to 11% of total heat use in Scotland by 2020. Renewable heat is the generation of energy for heating using renewable sources. Many renewable heat technologies are currently broadly cost-comparative with conventional heat sources over their lifetime. However, high up-front costs and poor awareness discourage consumers from taking them up. A global study released by the American Wind Energy Association (AWEA) on May 2009, flagged up significant international growth in demand for small wind technology. The British Wind Energy Association's (BWEA) own figures released a week before, recognised the UK as the world's biggest exporter of turbines in the sub 50kW division, last year deploying 4.7MW in international markets. The study's author Ron Stimmel of AWEA said: "The UK currently exports more small wind systems than any other country in the world and has a great potential domestic market." UK manufacturers currently hold an 82% revenue share of the UK market and export 50% of their output to over 100 countries worldwide. Benefiting from a weak British pound, 2008 export revenues for UK companies doubled and in the same year the sector created 500 new UK based jobs. Since 2005, over 10,000 small systems have been deployed in the UK, equating to over 20MW of installed electrical capacity. In total, this growing industry now provides 1,880 UK based jobs.

Market trends	**Technologies** Demand Side Management (DSM) is seen to be critical in securing energy supply for Scotland. This focuses on the ability of internet enabled technology to utilise and optimise the intermittency of renewable technologies to manage energy loads. Historically, Scotland is strong in research and development of low carbon renewable energy and enabling technologies. A large number of projects including more mature technologies such as heat pumps, micro-CHP, solar thermal, wind and PV have undergone testing at Scottish universities for a number of years. The associated infrastructure support has also received extensive attention from both grid-connected and isolated network architecture viewpoints. Scotland is well placed to provide expertise, consultancy and collaboration on technical issues ranging from energy supply to demand side research and development. Recent changes in Government policy to fiscally penalise those companies who do not actively control their energy use, such as the Carbon Reduction Commitment, will drive organisations to operate from low energy buildings. Markets are also growing for products such as LED lighting, wireless communication and smart metering. These products are in demand for energy efficient buildings and applications where energy management systems are utilised. **Renewable energy** The UK Small Wind Systems (SWS) sector continues to grow its contribution to national energy, with overall annual production estimated by BWEA to have reached 24.5GWh in 2008. Detailed information on SWS installations prior to 2005 is not readily available, however recent studies indicate that current annual energy production levels are a fraction of what may be possible in the future. BWEA estimates that if barriers to market growth are adequately addressed, by 2020 the UK SWS sector will be annually generating 1700 GWh (1.7 TWh) of renewable electricity. Small wind turbines, as opposed to micro-wind turbines, are expected to continue to provide the majority stake of annual deployed capacity. There are a number of drivers expected to encourage future growth of SWS technologies: • Increase in financial support under the Scottish Government's commitment to renewable energy • Implementation of feed-in-tariff style policies in 2010 • Streamlining of planning requirements • Environmental awareness • Energy security • Future fossil fuel price increases. In order to support the integration of renewable energy, it is expected that feed-in tariffs will come into effect as early as 2010. The feed-in tariff works by guaranteeing a long-term premium payment electricity generated from renewable sources and fed into the grid. Similar systems have already been adopted in mainland Europe and this is generally viewed as the best method of maximising the potential of renewable energy [12].
Scotland's strengths – current examples	**Technologies** Examples of Scottish companies who are currently developing new products and technologies in this area are as follows: • Solas lighting design and install LED lighting systems which are an option for environmentally friendly lighting technology, with the potential to draw less power, and produce less waste, than other lighting sources. • RLTec Ltd are a UK company with operations in Scotland who contracts with grid system operators to provide energy balancing services using appliances equipped with dynamic demand.

	Renewable energy (small scale) Examples of Scottish companies who are currently developing new products and technologies in the small wind industry are as follows: • Proven Energy, based in East Kilbride, is a global supplier of small wind turbines. They have installed over 2000 units worldwide and have patented a flexible blade system which enables the wind turbine to generate power in light or strong winds. • Renewable Devices, based in Edinburgh, have also developed a small wind turbine system with installations worldwide. In addition to this they have offer a complete service for the design, supply, installation, commissioning and operation of green energy technology to the public and private sectors. • Other organisations such as Ghia Wind and Windsave are developing solutions for domestic and commercial buildings which have potential both within the UK and worldwide. In addition to these organisations TUV NEL, based in East Kilbride are delivering a range of services to inform R&D, product development, installation and associated technologies in relation to wind energy. These include: • Blade design including aerodynamic and aerolastic modelling • Structural analysis • Vibration analysis • Wind resource assessment • Technical due diligence.
Barriers to development	**Technologies** Barriers to the development of these technologies include the following: • Product development costs at early concept stage • Time delays associated with time-to-market and product commercialisation • The ability for developers to retain the intellectual property rights • Quoted companies (e.g. Microsoft, Siemens, Cisco) have advantage of size and funds for development of products • Insurance/Warranty issues. **Renewable energy** There is a lack of any significant publicity promoting renewable heat technologies in Scotland. In addition to this, public procurement policy has not been used officially in Scotland to encourage renewables. However, some local authorities, care trusts and other public agencies have voluntarily adopted policies to use renewable energy and other sustainable technologies where possible. At present, much of the renewable heat plant is manufactured outside of Scotland and imported. This means that little of the money spent on technology is retained in Scotland. This is highlighted by information from the 'Clear Skies' programme which was the original list of registered microgeneration products and installers that could be used when applying for microgeneration grant funding. Of the 1158 installations listed on the Clear Skies programme in 2007, only 16 (1.4%) involved products manufactured in the UK. However, some companies have indicated interest in establishing manufacturing capability in Scotland. This will be dependent on clear, stable and sufficient Government support to stimulate the market demand.

Opportunities for development – Domestic	**Technologies** There are several potential markets for technologies and systems either in or near a pre-commercial development phase. Isolated and integrated hybrid energy systems are an increasing market opportunity. They are employing renewable sources to supply part of, or all of, the entire energy requirement for a system by utilising energy storage. As the development of intelligent control systems improves and costs reduce, the trend will be towards the investment in larger and more complex hybrid systems. In addition to this, there is the possibility to extend the concept to building integrated domestic systems such as CHP. The Technology sector area is the least developed of the defined low carbon built environment sector in the United Kingdom. However, there is currently vast amounts of research activity in this area that is quantified by the levels of funding calls. Demand side management of energy is required to be developed in parallel to the implementation of renewable technologies to secure future energy supply. The following are areas where intervention would provide growth: • Use of broadband to support demand side energy management technology • Boilers and thermal plant systems. This requires technology push through applied R&D on boiler and burner design, combined with technology pull in the form of regulation and development support • Advanced controls for building management systems including home networking systems. This requires technology push through demonstration schemes and technology pull through regulation • Advanced application of light emitting diodes (LEDs). This requires fundamental R&D followed later by regulation and Government procurement policies • "Dematerialisation / lightweighting" and decarbonisation of products. This requires fundamental R&D as technology push followed by network support and information exchange. Key to enabling growth in this sector area is for SE to broker engagement with Scottish organisations to bid collaboratively into funding streams that enable product development and commercialisation. This would include marrying events with funding calls from organisations such as Technology Strategy Board (TSB), which is already being supported by the Scottish Construction Centre (SCC). The SCC's role in facilitating such events will enable supply chain engagement. **Renewable energy** Based on projections made by the Scottish Renewables Forum [11], the renewable heat industry could generate a turnover of £2.7billion in the renewables sector by 2020. Further estimations state that £0.9billion of this value could be retained in Scotland over 10 years. This represents around 34% of installed value being retained in Scotland. These projections are based on conservative estimations. If a sustained demand for renewable heat was established in Scotland, more manufacturers would invest in the country, allowing a greater proportion of the value to be retained. These projections could also have a positive effect on the associated supply chains e.g. biomass, wood pellet, etc. A number of sources suggest that the 11% target will be met primarily through biomass. If this transpires, up to eight manufacturers, each producing 100,000 tonnes of material per annum, would have to be established [11]. Presently, installations of this nature utilise wood which is deemed unsuitable for construction or other uses. However, if the market expands biomass will increasingly compete with other sectors for forestry and wood supplies. This, in turn, will stimulate the expansion of the associated supply chain. The number of UK-based jobs provided by the SWS sector continued to rise in 2008. Based on current industry practice, it is estimated that for every manufacturing company level employee, there are two jobs created upstream (supply chain, components, etc), and a further two created downstream (e.g. installer, distributor, etc).

	The British Wind Energy Association (BWEA) estimates that by 2020, the SWS sector could be employing 5,800 people with a market revenue size of more than £750 million. Assuming UK market saturation and continued participation in fast expanding export markets, BWEA estimates that the UK SWS sector could provide over 10,000 UK-based jobs and revenues measured in the billions of pounds annually. UK manufacturers of SWS doubled the size of exports in 2008. This resulted in UK manufacturers exporting 50% of output to over 100 countries worldwide. Sharp increases in annual deployment are expected for 2010, when feed-in-tariff policies are expected to be implemented to better incentivise technology uptake. In 2010 it is expected that more turbines will be exported by UK manufacturers than will be deployed within the UK market. Rapid increases in exports are being aided by current rates of exchange on the UK pound and growth in global demand.
Recommendations	Recommendations for this sector include: • Public sector could develop a strategy to promote and support the development of manufacturing to support the renewable heat and SWS sectors. This could be achieved through central funding and procurement policies to stimulate the demand across the industry. • Closer collaboration with colleges and universities to input renewable technologies into education courses has the potential to remove barriers of awareness, maintenance issues and financial viability of technologies over the longer term. This also has the potential to remove the requirement for expensive accreditation processes for products and suppliers due to increased knowledge and awareness. • Building Standards Division to get involved in the development of educational course material to inform the future direction of the regulatory framework.
Conclusions	The technologies and renewable energy sub-sector is a growing industry and is vital to the development of the low carbon built environment. In particular the requirement for renewable energy sources, such as renewable heat and small wind, should act as a catalyst for the expansion of this industry sector. The barriers are not insurmountable if a mechanism is established to reduce upfront capital costs and provide supportive procurement processes.

LCBE sector area – Professional services	
Definition	Professional services have been defined for this study as those individuals or organisations who are involved in planning, designing and specifying buildings.
Sector overview	The professional services sector is responsible for planning, architectural design, engineering design and facilities management. The UK employs 209,000 professionals earning a fee income of £11.6 billion, which equates to GVA of £55,480 per employee in the UK. The current economic climate is proving difficult for the professional practices in Scotland, with large organisations cutting staff numbers significantly as private sector struggle to secure finance for projects. There is, however, a relatively healthy export market for the professional services on offer in Scotland. The Construction Statistics Annual (2008) [13] states that in 2006 some £156 million of architectural services were exported from the UK. In addition to this, £107 million in surveying services and £126 million in construction services were exported in the same period. These are UK figures but taking an estimate of 10% share for Scotland, this is still a considerable export market in professional services. Other areas of activity in Scotland are within the design and development of simulation tools for designing and assessing the energy performance of buildings.
Market trends	The aim of meeting low carbon building targets at an affordable cost is a key challenge for the design-client relationship. In order to drive forward this agenda there is a requirement to increase best practice in the market place to ensure that perceived risk of design innovation is removed as an obstacle. The economic downturn has seen many organisations undertake a review of services available within their organisations to identify areas where they have potential to maintain turnover levels, e.g. engineering practices normally concerned with new build, undertaking Energy Performance Certificates for building owners.
Scottish strengths - current examples	**Architectural practices** RMJM is an international architectural practice, based in Scotland, with offices throughout Europe, the Middle East & Africa, Asia-Pacific and The Americas. Their work includes architecture, sustainable design, urbanism, masterplanning, interior design and research and development. RMJM also operate culturally diverse studios made up of over 1000 architects, designers and creative thinkers - comprising 50 nationalities - working on projects in over 20 countries worldwide. Other examples of architectural practices operating in the low carbon built environment include John Gilbert Architects, Kraft Architecture, 365 Architecture, Malcolm Fraser Architects, Nord Architecture, 3D Architects, Keppie Design, Faithful and Gould, Turner & Townsend, etc. **Simulation tools** Integrated Environmental Solutions (IES) is an innovative company, based in Glasgow but with offices worldwide. They are at the forefront of the development and application of powerful software simulation tools and consulting services for architects, engineers and others involved in the design, development and management of sustainable and low carbon buildings.
Barriers to development	Recent studies by Carbon Trust on schools concluded that new build schools in Scotland performed poorly in both their heat and electric requirements in comparison to England and Wales. The report highlighted that low carbon design was not a key driver and that this was primarily due to the fee structure by design consultants as they take a percentage of the capital cost. As traditional ventilation systems are expensive the mechanical and electrical engineer has no incentive to deliver buildings with less expensive kit

	as this will affect their final fee. However, a key barrier as a result of the downturn has been the downsizing of employees at a time when designers will be challenged to meet low and zero carbon design at an affordable cost.
Opportunities for development – Domestic	In the domestic sector awareness training/development is where biggest impact can be made. The Innovation Park at BRE Garston has had a large amount of visiting design professionals who see the benefit of a physical facility that allows them to ask questions and see what alternative solutions are available on the market. Opportunities also exist when working with Carbon Trust and Energy Saving Trust to ensure opportunities are realised for consultants when grant funding is made available to develop projects. It may also prove useful to develop a directory from which to source low carbon products that could be used by design professionals when designing low carbon buildings. BRE has already developed a European database of materials through recent involvement in a EU funded project. It is BRE's intention to expand this database using products and technologies being demonstrated on the Innovation Park at Ravenscraig.
Opportunities for development - Global	The UK has strength in the design ability of architects and engineers to design to low and zero carbon standards, with Scottish companies involved in projects across the globe. In developing countries such as in Eastern Europe and South America there is very limited design ability and by fostering stronger relations with such countries project work could be realised for Scottish companies. However, the cost to bid for work in such regions is a risk that some organisations would not want to carry without relevant support being provided.
Recommendations	Recommendations for this sector area are as follows: • Providing support to designers could secure project work across the globe. This could involve financial support related to the cost of bidding. • Supporting training/awareness raising facilities are developed to address the design elements relating to low carbon buildings. Demonstration facilities such as the low carbon house at South Lanarkshire College, the proposed project at Riccarton by Heriot Watt University and the proposed Innovation Park at Ravenscraig will assist developers in addressing how to meet low and zero carbon standards at affordable rates for clients. • Signposting to relevant directories of products that define environmental performance of building materials should be made available for design professionals. The Carbon Trust has stated that they are in the process of looking into the issue of counting carbon of building materials.
Conclusions	The design community are well placed to deliver the low carbon solutions on a global scale. The cost of providing solutions to clients is, however, sometimes seen as overly expensive and unattractive. Raising awareness of alternative products that could be specified for low carbon design will be key to ensuring a change from standard design specifications to low carbon solutions.

LCBE sector area – Research and development	
Definition	Through prominent Universities, Scotland has significant strength in its R&D activities in relation to the low carbon built environment. In addition to this, organisations such as BRE and NEL provide additional R&D and product development support to the industry.
Sector overview	The Scottish University Education Sector is worth £2.2billion with 20 Higher Education Institutions, 18 of which are active in research and testing activities. The University sector has played an important role in bridging the gap for companies to bring products to the market. The Knowledge Technology Partnership has accrued an average of £220K per company. 13% of Higher Education Institution owned active spin-out companies are based in Scotland. The majority of Scottish Universities attribute an average of £0.09/£1.00 of Research and Knowledge Transfer income with up to £0.36/£1.00 being attributable to the modern universities such as Edinburgh Napier University. More interaction is required, however, between industry sectors and the economy to actively link research outputs from Scottish universities [14]. Private sector organisations who provide testing facilities are often in competition with Universities. With overhead costs associated with the maintenance of these facilities, demand for use has been driven down as cost to cover testing has risen. Facilities such as BRE's testing laboratories and BPAC's Hangar 17 (in collaboration with Edinburgh Napier University), are attracting research and development clients from Scotland, UK, Europe and North America. Both of these facilities are privately funded and receive not public funding in the promotion of their services. Construction products require testing to validate their performance, which is a key source of information for use in certification schemes such as Code for Sustainable Homes. However, it has been noted that the maintenance and calibration of this equipment is expensive as is decommissioning, making utilisation a high priority for organisations. It is often felt by academia and industry that there is a gap between research and development activity and testing for market acceptance. A recommendation from academic organisations is that physical testing facilities are further developed and made available for the industry to utilise.
Market trends	The requirement to provide data on building products and technologies is a key driver for collaboration between product manufacturers and university/private research organisations. Universities however charge out commercial costs for services undertaken at their facilities and this has provided a level playing field in terms of competing for business in the market place. However, as the requirement to provide environmental data for products and innovation in supply chain collaboration increases, the trend for engagement with research and testing facilities will grow.
Scotland's strengths – current examples	Examples of organisations who are currently involved in R&D in this area are as follows: • University of Strathclyde Energy Systems Research Unit (ESRU) provides advanced research activities and findings for academics and practitioners interested in building energy efficiency. This includes new and renewable energy systems deployment at both the strategic and urban scale. The University of Strathclyde, Energy Systems Research Unit (ESRU) have been at the forefront of much of the global research on demand side management (DSM). Demand side management is considered as a potential solution to the problem of matching electricity production and consumption levels. Passive DSM methods such as offering different tarrifs for daytime and nighttime use, and promoting energy efficient appliances have been investigated for domestic buildings. • The Mackintosh Energy and Architectural Research Unit (MEARU) at Glasgow School of Art, undertakes strategic and applied

	research into sustainable environmental design. • The Centre for Timber Engineering (CTE) at Edinburgh Napier University, engages in a wide range of research activities relating to the use and development of timber products. This includes applied research conducted in close partnership with commercial organisations to long-term strategic research to address the future needs of the industry. • The Building Performance Centre (BPC) at Edinburgh Napier University is one of the leading UK centres for applied research, knowledge transfer and consultancy for the built environment. It has national and international recognised experts who cover a wide range of disciplines including; construction product research and development, development of technical standards, robust details and building regulations, sustainable construction, building diagnosis and material performance.
Barriers to development	Barriers to the development of this sector area include: • Proof of concept (POC) funding takes a long time from application to realising the project concept • Demand for technology if often lacking from the construction industry • Lack of appetite to finance projects • Some research facilities are in competition with research projects being run by universities • Calibration and maintenance costs are high for test and validation kit • Inconsistencies in decision-making process in relation to grant/research funding applications • Construction and built environment research and knowledge transfer funding in Scotland has often been less of a priority in relation to other sectors.
Opportunities for development – Domestic and Global	From the questionnaire and interviews carried out by BRE, it was suggested that Scotland has a strength in its academic base and in some cases was stated as being world leading in the low carbon field. The opportunities in this sector focus around academics working with product manufacturers and designers. With product manufacturers the focus is on provision of data relating to the environmental performance. This involves engaging with various parts of supply chain to identify product performance. With designers the use of modelling tools is a critical element in determining an overall energy rating for the building by use of dynamic simulation models to provide performance assurance of the building in use. Both activities are not restricted to research partners working with Scottish clients. Promoting the excellence in this area which exists in Scotland has potential to encourage global interest. Links with universities across the globe also presents the opportunity for supply chain engagement and opportunities for Scottish companies to export products. The testing and validation facilities can also be utilised by organisations across the globe if they are marketed effectively. Respondents to the questionnaire indicated that they were currently utilising Scottish facilities as opposed to looking elsewhere in the UK or Europe and beyond.
Recommendations	Recommendations for this sector area include: • Creation of a resource map of testing and validation facilities for promotion to global market • Evaluation of timescales of funding programs for products being tested for future development • Development of a facility to bridge the 'valley of death' from product development to market acceptance • Encourage development of mini Knowledge Transfer Partnerships • Encourage engagement with research partners in Europe and beyond to penetrate markets.

Conclusions	Throughout the consultation process carried out in this work, it has been clear that Scotland has strengths in its academic base. Therefore, this should be exploited to the advantage of all parts of the supply chain. The ability of universities to foster engagement with foreign counterparts could also provide opportunities for export markets of newly developed products.

4 Qualify Scotland's strengths in the LCBE sector

Objective: Qualify and validate the strengths that Scotland has in the LCBE sector

The Scottish Government has set some of the most ambitious targets for carbon reduction in the world. It has also pledged a significant investment in the development and utilisation of renewable technologies. The Sullivan Report and Climate Change (Scotland) Bill identify the targets that the industry in Scotland will have to meet. These policies will drive the market harder and faster than anywhere else in the world. This presents significant challenges, but also real opportunities for the industry in Scotland and its export potential. Investment in the industry is, therefore, essential for two main reasons:

1. To help Scotland achieve its carbon reduction targets using Scottish products and technologies wherever possible, and
2. To allow Scottish businesses to maximise their potential in competing in the global low carbon economy.

At present, the industry as a whole is making tentative steps towards low carbon products and technologies. Some organisations are forging ahead with new products and innovations that will help towards the future targets for energy and sustainability. Developing products and achieving 'first to market' status will allow organisations and their supply chains to grow, with the obvious benefits to the Scottish economy. Much of this activity is fragmented at the moment. Coordination of these activities with some clear objectives and financial support will drive the industry forward at an increased pace and with greater impact both nationally and internationally.

If Scotland can achieve the ambitious targets presented by the Government, Scottish businesses have the potential to be viewed as world leaders in developing a low carbon market. This is achievable given the relatively small size of the Scottish industry and the particular strengths that exist (described in Sections 3 and 6 of this report).

4.1 Market attractiveness

Scotland has significant natural resources which can be used to develop parts of the industry operating in the LCBE sector. Wind, tidal and hydro energy will have a significant role to play if the renewable energy targets set by the Scottish Government for 2020 are to be realised. These targets should stimulate investment to drive the manufacturing, installation and maintenance of the associated products and technologies. The market in renewable energy has the potential to grow significantly in Scotland, as described in recent reports from the Scottish Renewables Forum and the British Wind Energy Association.

Timber is another natural resource which is often under utilised in Scotland. There is an abundance of timber produced in Scotland, with approximately 5million cubic metres being produced annually. Through innovative manufacturing techniques, such as SIPs panels and massive timber products, this can be processed to provide a strong and durable building material. There is the potential for investment in the area to provide the manufacturing base which will allow Scottish timber to compete with imported material and, indeed, facilitate the export of manufactured timber products.

4.2 Supply chain

Scotland's construction supply chain is well established both nationally and internationally. The emerging LCBE sector is not mature enough at present to have established supply chains which extend into mainstream construction. Supply chains are developing around specific products and technologies however these are relatively removed from standard construction practice.

As demand within the industry grows for LCBE products, supply chains will emerge and quickly become established. This will be a slow process unless the level of demand is stimulated by regulatory or legislative-driven targets.

The main strengths of the industry sub-sectors (identified in Section 3) can be summarised as follows:

Building envelope

Materials and products

- Research into the development and use of Scottish timber in construction has been ongoing for s number of years. Recent advances in timber grading, sawmilling processes and quality control has seen an increase in the use of nationally sourced timber in structural framing, timber panel products and MMC systems. The forestry industry is now primed to deliver locally-sourced raw material for the construction industry. This has obvious benefits for the associated supply chains, rural areas, forestry management, as well as sustainability credits. Reducing timber imports and investing the capital in the Scottish industry will quickly establish a growing market for Scottish timber in the emerging low carbon industry. The Centre for Timber Engineering (CTE) and the Forestry Commission have published documents on the use and benefits of Scottish timber products in recent years [15] [16].
- Development of new materials for use in low carbon buildings is also ongoing in Scotland. The manufacture of insulation material from recycled products is not new to the industry, however, some recent product initiatives have extended this activity to maximise low carbon benefits. Kraft Architecture have prototyped an insulation product from textile waste, the basic material for which is being supplied by Scottish companies. BuildICF are also looking to harvest waste products for the moulds used in the insulated concrete formwork system. They are keen to set up a recycling and manufacturing base in Scotland and have already begun to export their products internationally.

Offsite manufacturing

- Offsite manufactured systems are being developed in Scotland to meet the future energy targets for domestic buildings. These include closed panel timber systems and lightweight modular steel systems. Companies such as CCG (Scotland), Scotframe, Stewart Milne, Powerwall and others have invested in developing these systems. Encouraging the use of locally sourced products in the manufacture of these systems would have a positive effect on associated supply chains.

Technologies

Renewable energy

- Scotland has the potential to utilise its significant natural resources for renewable energy. Small wind systems manufacture and deployment is growing in the UK and Scotland and this is likely to expand further due the Scottish Government targets for renewable energy [3] [10]. Renewable heat has been given a particular focus from Scottish ministers and the Scottish Renewables Forum has identified significant growth potential for associated technologies and supply chains.

Demand side management

- DSM is seen as a critical element in the energy utilisation sector. Much of the R&D work has been carried out in Scotland and is being commercialised by Scottish companies such as IES. The uptake of this technology will result in a demand for associated sensor and wireless technology which could be developed in Scotland, where, historically there has been significant levels of economic activity.

4.3 R&D capability

Scotland has world leading academic facilities in energy management, building product development and design. These facilities include some 85 testing facilities that include testing structures, products and technologies. Recent BRE surveys indicate that the industry in Scotland is not fully aware of the testing capabilities that are available nationally. Scottish Enterprise has identified this as being an area where greater integration between the industry, academia and testing facilities is required. Various models are being explored which will provide an information portal for the industry to build stronger relationships with testing organisations and Universities.

Of all the Scottish Universities providing courses and research activities in the built environment, many have a portion of their research categorised as 'world class'. Classification of research output is carried out annually in the Research Assessment Exercise (RAE). The last assessment, carried out in 2008, identified eight Scottish Universities who had research activities relating to the built environment which were classified as 'world class' (or a 4* RAE rating). These Universities and their research activities are listed in Appendix 2.

4.4 Promoting the use of homegrown Scottish timber

During consultation with the industry, it was suggested that Scotland's timber harvest would double over the next ten years, and continue to grow in the following period. Historically, homegrown Scottish timber has not been used extensively in timber frame buildings due to reservations about its strength characteristics in comparison to Scandanavian material. This perception is gradually being overcome through strategic research activities by organisations such as the Centre for Timber Engineering (CTE) at Edinburgh Napier University.

Low carbon buildings, and in particular domestic buildings, have the potential to use more homegrown Scottish timber as the industry moves towards Modern Methods of Construction (MMC). Products such as laminated timber, SIPs panels and massive timber components can be manufactured from Scottish timber. Creating a demand for these products through the promotion of MMC systems would have benefits for Scottish companies across the supply chain.

4.5 Demand side management

From consultation with experts in this field the ability of Scotland to provide a secure energy supply to buildings will be attractive to companies in consideration of basing their operations in Scotland. In areas such as London, the possible future threat of 'brownouts' and 'blackouts' causes concern to large businesses. These organisations often require consistent, uninterrupted energy supply to their server systems. Recent press announcements about placement of 'Green Data Centres', is a signal that underpins this potential. Data Centres are used by large organisations such as banks and IT providers to host their servers, data banks and other central storage equipment. These data centres are dependent on continuous and reliable energy supply. 'Green Data Centres' are similar in function however they operate under greater levels of energy management and look to identify ways of managing the threat of security of supply.

4.6 Renewable heat

Increasing the level of energy generated domestically will enable Scotland to be less dependent on imports of fuel from abroad. It is estimated that increased investment in renewables in the UK to meet a 11%

renewable energy target in 2020 will reduce UK gas imports by 11-14% in 2020. Scottish Renewables Forum [10] quantified the economic growth potential within the renewable heat industry as £2.5billion in growth, £0.9billion in retained investment, with the creation of 1900 new jobs. Scottish Government has also paid particular attention to the development of renewable heat in the Climate Change (Scotland) Bill.

The creation of the manufacturing base required to support this demand could allow Scotland to export products and services in relation to the renewable heat industry.

5 Identifying key linkages between LCBE and SE priorities

Objective: Identify key linkages within the LCBE sector and SE priority industry strategy

5.1 Digital markets and enabling technologies

As the security of energy supply issue becomes more critical, there will be a greater emphasis on the need to be innovative in the use of digital and demand side management technology. The use of BEMS (Building Energy Management Systems), Smart Metering and internet to control energy are just some of the technologies emerging within this sector. The Technology Strategy Board and ITI Energy are currently funding technologies that will address the LCBE sector and will compliment outputs from this study. This includes investigation into managing office equipment and white goods. It is perceived that the energy produced by such technologies will be included in any calculation for net zero carbon accreditation as is signalled by CLG report on defining zero carbon.

5.2 Energy

As energy legislation tightens there will be less scope for the building envelope to meet the energy targets set in SAP or SBEM to pass building standards. This will drive the requirement to produce energy onsite by use of microgeneration or community-based schemes. Such technologies such as wind, heat, biomass, CHP will require development to meet mass market roll out. This will include input from the design community to specify such systems for buildings and communities.

Currently, there is development activity in Scotland in relation to fuel cell technology. This is being driven forward by strategic research within universities (Dundee, St. Andrews and Edinburgh Napier) and supported by SE.

5.3 Construction

The building envelope has a critical part in defining the energy performance and carbon calculation of a building. The sustainable procurement and production of the products within the envelope is often measured by an eco point system. This provides clients and specifiers with information on the capital carbon calculation of their building. The GreenBook (www.greenbooklive.com) is a reference guide for specifiers when choosing construction products by their environmental performance. ‘A’ rated products are generally a requirement of a BREEAM rating, the assessment methodology utilised by public sector and private sector organisations to validate environmental performance of their building.

In addition to product selection there is also a drive on lean construction techniques to minimise the carbon impact during site construction. The Scottish Construction Centre has rolled out seminars in this area to encourage uptake as cost savings also accrue.

Education of construction workers will be a critical issue for construction industry as there is change in process and products used to meet the low carbon agenda.

The construction industry in Scotland remains fragmented and this acts in opposition to the emerging low carbon sector. Many Scottish construction companies have up to 70% of their economic activity outwith Scotland and within the rest of the UK. There is a need for clarity on how domestic buildings in Scotland will be assed in the future with regard to their energy and sustainability performance. Professor Sean Smith of Napier University has stated that the adoption of the Code for Sustainable Homes in Scotland would assist Scottish companies in exporting their products across the UK. The adoption of the Code would negate the need for different product specification for the varying assessment methodologies currently used across the UK.

5.4 Forestry

The use of Scottish timber in MMC systems has been identified as an area for possible development in the LCBE sector and this would also have a positive impact on rural areas. This would have an additional positive impact on the supply chain from sawmillers, to manufacturing, installation and design/specification. In addition to this, continuing R&D activities will be required to drive forward the commercialisation of laminated timber and massive timber products and to make them accessible to the industry on a wide scale.

6 Identifying failures and opportunities to grow

Objective: Identify the key market failures and propose opportunities to grow the LCBE sector

From the research carried out by BRE, clear feedback was obtained from the industry on the market failures and opportunities for growth in the LCBE sector.

6.1 Market failures

The key market failures were identified through extensive consultation with the industry. This consultation included:

- An online survey of Scottish companies with more than 200 responses
- An industry workshop attended by thirty invited delegates
- Interviews and contributions from industry 'experts'.

The views expressed during these consultations were consistent and alluded to a **lack of demand** for low carbon products and a **fragmented approach** to the development of new products and technologies. These were seen as the main barriers to the development of the LCBE sector in Scotland.

Further examples of market failures were identified and are described under the headings below.

Knowledge. A lack of knowledge within the industry supply chains and the public in relation to low carbon products is a barrier to the development of the LCBE sector in Scotland. Knowledge of future energy reduction targets, Government policy and the benefits of low carbon buildings and products has not penetrated every level of the industry. This will affect the level of specification and therefore demand for low carbon products and technologies.

Investment. From the industry consultation carried out by BRE it is clear that a lack of investment in supporting Scottish companies in developing low carbon products is a barrier to the growth of the LCBE sector. Organisations are generally aware of the funding streams available, however these have been under utilised due to a lack of clarity on specific support mechanisms available in this field.

Competition. Due to the current immaturity of the market and the lack of demand, significant competition does not exist within the industry at present. This can contribute to high investment and upfront capital costs, creating a barrier to the development of the LCBE sector.

Perceived demand. There is evidence that there is a lack of perceived demand for the development of low carbon products within SMEs. This is in part due to a lack of awareness of the potential benefits of being involved in product development and innovation, and the commercial spin offs that are possible. Even if SMEs are aware of these benefits, they may not wish to pursue funding due to the complexity of the processes and the possible market failure due to the perceived demand for low carbon products.

Externalities. Constructing and upgrading buildings to current standards will achieve certain levels of performance with respect to energy and sustainability. By utilising products and technologies with higher performance and lower environmental impacts, greater savings in carbon emissions are possible. If low carbon products and technologies are not specified and utilised, buildings will continue to require greater heating and electrical loads than could be achieved, incurring greater costs for the building occupiers. Opportunities to reduce wider environmental impacts will also be missed, such as a reduction in greenhouse gas emissions and waste. Highly insulated, well designed and constructed, and technically advanced homes could significantly reduce fuel poverty, social exclusion and the overall domestic energy demand in Scotland.

During the consultation with industry, further specific market failures were identified as follows:

- Lack of strong legislative and/or regulatory framework to promote low carbon products and technologies. At present, the Regulations and Standards do not, in most cases, specify low carbon products or technologies, MMC construction technology, promote recycling, or green credential products. This causes the industry as a whole, to not specify or procure low carbon products. This will change in the years to come, however, there exists an opportunity to stimulate the industry before legislation dictates through industry standards such as Scottish Ecohomes or a Scottish Code for Sustainable Homes.
- Lack of demand from developers/clients for low carbon solutions. The capital cost of low carbon products and technologies often places them at a disadvantage in relation to other products. This can be caused by misconceptions about payback periods and the efficiency of certain products. This will change naturally as more data on system and product performance becomes available, however greater dissemination of research at this stage may accelerate this process.
- Lack of awareness across the industry – no clarity in the short and long-term benefits of low carbon buildings/technologies. Public perception of low carbon solutions varies greatly. This has an affect on the overall demand for the products. This is particularly problematic in social housing where tenants may be asked to contribute to new technologies which they may never see the benefits from.
- Absence of demonstrations of low and zero carbon buildings/technologies – how can a demand be created when nobody can ‘see’ the product. The application of new technologies will be hindered to an extent by the lack of visibility of installations. The public and clients are less likely to request products if they cannot see them operating within a building.
- Lack of information targeted at developers, public, specifiers. Information should be tailored for specific groups. Public perception of low carbon products will change as they become more commonly applied. However, information should be provided which can engage with the public on how products can contribute to energy saving in an economic sense.
- Barriers for new products being recognised within material and products databases can present a significant hurdle for the commercialisation process. Calculation processes such as SAP (Standard Assessment Procedure) and SBEM (Simplified Building Energy Model) utilise databases of products for their energy assessment. It is often difficult for new products and technologies to be recognised within these processes which will delay their uptake by the industry.

6.2 Opportunities within the LCBE sector

Within the Building Envelope sub-sector, a number of organisations are developing new products and systems which will contribute to the emerging low carbon built environment in Scotland. These include Stewart Milne, Powerwall, BuildICF, CCG (Scotland), BSW Timber, Scotframe and James Jones. All of these organisations are developing products or solutions that have the potential to be used in low carbon buildings, and particularly housing.

These companies have a development and manufacturing base in Scotland. They are developing products which will focus on off-site manufacturing, high quality workmanship, reduction in waste and utilisation of Scottish material. There is potential to support these organisations in a number of ways:

1. Providing funding for the development of their products and/or manufacturing capability
2. Supporting mechanisms which create a demand for these products, through pre-commercial procurement for example
3. Providing a platform for dissemination of new product information and engagement with the wider industry
4. Stimulating the demand for new systems and products.

Throughout this research the current lack of demand for low carbon products and services has been highlighted. This has also been highlighted in a recent UK Government report on low carbon industry strategy. One way of creating a demand for specific products could be through a pre-commercial procurement model. This system could be used in the procurement of social housing and a specification placed on the use of locally sourced products within offsite manufactured systems. Indeed, the pre-commercial procurement model could be adapted to stimulate the demand for a range of products and technologies.

The utilities and renewables sub-sector has some clear opportunities that could be supported by SE. Renewable heat has the potential to create new technologies and associated jobs in Scotland. This may be more difficult to achieve in the short term due to the absence of an existing manufacturing base, however the possibilities remain. This has also been identified as an area for ministerial support in the recent Climate Change (Scotland) Bill (2009) and is, therefore, a key area for support.

The cleantech economy has remained relatively strong throughout the economic downturn and this has supported the growth of the small wind system industry. This area of growth is particularly strong in the UK and fits well with SE's involvement in this industry sector. Scottish based firms such as Proven Energy, Ghia Wind and Windsave would benefit from central funding from SE to develop and market their products effectively within Scotland and beyond. This may help to promote small wind systems to a variety of clients and developers.

The Technologies sub-sector described recent research and development activities that have been carried out in relation to demand-side management. Much of this technology has been developed with input from Scottish Universities but has not been utilised to any great extent within the industry. Commercialising this technology and specifying its use has immediate benefits for product development and manufacturing. There would be further benefits for the Scottish economy by promoting the 'security of supply' agenda to large organisations who may wish to relocate to Scotland. This is a long term and strategic goal and would need careful planning and engagement from the industry.

7 Conclusions

This research has highlighted the opportunities for Scotland in developing the low carbon built environment. It has also indicated that SE can make positive intervention to the LCBE sector by undertaking some key actions and interventions. It has been concluded that the industry is developing products and technologies to meet the future low carbon targets, however it is primarily in isolation and a more coordinated approach is desired. SE can support the industry in developing products for use in Scotland and beyond by engaging in the following activities:

- Develop and refine proposals for SE support of innovation programmes specific for the LCBE which are geared towards the construction sector timelines and demand factors
- Assist in stimulating wider demand for low carbon products and technologies by:
    - Mapping the R&D, test facilities and key experts which exist in Scotland
    - Identifying where product development activities can be supported through closer collaboration with research centres and testing facilities
    - Develop support mechanisms across the supply chain which can address market failure and assist in developing and promoting new products, markets and supply partnerships
    - Identifying the potential for a demand driven support model to encourage the specification of low carbon solutions
    - Establishing a specific support team funded by SE for the next five years to assist and drive forward SMEs and product innovation in the LCBE sector [14].

These activities should be flexible in their approach so that changes in legislation, market conditions and customer focus can be accommodated.

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Appendix 1 – Company's House SIC code data

GVA calculations were carried out on a sample of companies from this list. The company's were selected based on the availability of information and their activity within the industry.

Based on feedback from the industry, the % of business activity related to the LCBE was estimated at 40%.

			Number of companies			
SIC	**Activity**	**Total**	**BE**	**Technologies**	**R&D**	**Professional Services**
2010	Sawmills	99	99			
2020	Mfr of veneer sheets and plywood	3	3			
2030	Mfr of builders, carpentry and joinery	123	123			
2051	Mfr of other wood products	118	118			
2611	Mfr of flat glass	17	17			
2612	Shaping and process of flat glass	11	11			
2613	Mfr of hollow glass	2	2			
2614	Mfr of glass fibre	9	9			
2615	Mfr of other glass inc technical	17	17			
2640	Mfr of bricks	15	15			
2651	Mfr of cement	3	3			
2652	Mfr of lime	1	1			
2653	Mfr of plaster	1	1			
2661	Mfr concrete goods for construction	32	32			
2662	Mfr plaster goods for construction	5	5			
2663	Mfr of ready-mix concrete	19	19			
2664	Mfr of mortars	6	6			
2666	Mfr other articles of concrete	9	9			
2670	Cutting	19	19			
2710	Mfr basic iron	49	49			
2742	Aluminium production	7	7			
2743	Lead	1	1			
2744	Copper production	4	4			
2751	Casting of iron	10	10			
2752	Casting of steel	9	9			
2753	Casting of light metal	5	5			

2811	Mfr metal structures & parts	315	315			
2812	Mfr builders' carpentry of metal	7	7			
2822	Mfr central heating & rads	1				
2923	Mfr non-domestic ventilation	12				
2972	Mfr non-electric domestic appliance	5				
3001	Mfr office machinery	3				
3110	Mfr electric motors	40				
3120	Mfr electricity distribution	6				
3150	Mfr lighting equipment and lamps	20				
4012	Transmission of electricity	14				
4013	Dist and trade in electricity	53				
4022	Dist gaseous fuels through mains	13				
4030	Steam and hot water supply	13				
4521	Gen construction & civil engineering	4482	4482			
4522	Erection of rook covering frames	348	348			
4525	Other special trades construction	1105	552	350		
4531	Installation electrical wiring etc	1031		1031		
4532	Insulation work activities	89	89			
4533	Plumbing	901				
4534	Other building installation	700		700		
4541	Plastering	150	150			
4542	Joinery installation	1261	1261			
4543	Floor and wall covering	n/a				
4544	Painting and glazing	n/a				
4545	Other building completion	847	847			
7310	R&D nat sciences & engineering	527			527	
7420	Architectural	2270				2270
7430	Technical testing and analysis	477			477	
	TOTALS	**14029**	**8645**	**2110**	**1004**	**2270**
			BE	Technologies	R&D	Professional services

Appendix 2 – RAE classifications for Scottish Universities

The list below gives Scottish Universities and their research areas which were awarded a 'world class' (or 4 star) RAE rating. The information below indicates who much of the research activity (as a percentage) was awarded a RAE 4* rating.

University	**Research area**	**Percentage of activity given a 'world class' (RAE 4*) rating**
University of Dundee	Civil engineering	15%
	Architecture and the built environment	5%
University of Edinburgh	Architecture and the built environment	25%
University of Glasgow	Civil engineering	15%
Glasgow Caledonian University	Architecture and the built environment	15%
Heriot Watt University	Civil engineering	5%
	Architecture and the built environment	10%
Edinburgh Napier University	Civil engineering	5%
	Architecture and the built environment	5%
Robert Gordon University	Architecture and the built environment	10%
University of Strathclyde	Electrical and electronic engineering	15%
	Civil engineering	5%
	Architecture and the built environment	5%