

## Appendices

### Appendix 1: Developing the low carbon and climate change research criteria

In order to produce research results that would benefit Climate-KIC WM and other local partners, we sought to develop a series of criteria that could be used and then combined in different ways in the future, depending on future priorities.

For example, our analysis of Climate-KIC themes showed that many of the identified priorities and activities did not always fit within one theme. Also local partners might want to combine activities within their own interpretation of a theme. For example, the West Midlands Combined Authority and Birmingham Science City are interested in building on this work to develop a future baseline of key research strengths.

Therefore, we conducted our analysis of a range of key published and unpublished materials identified by Climate-KIC WM and our research team to help identify the common climate change priorities and definitions that would contribute to a lower carbon and resilient economy. The results of this analysis are in Table A1.1. We then used these results to devise a summary set of search criteria for the research. These are set out in Table A1.2.

**Table A1.1: Summary of analysis of climate change themes and elements, priorities and definitions to inform the research criteria**

Climate Change themes and elements contributing to a lower carbon and resilient future.  Presented under key areas of global greenhouse gas emissions (GHG) and then Climate-KIC themes.	International and Climate-KIC Climate Change Priorities and Definitions					UK and West Midlands Climate Change Priorities and Definitions				
	5 <sup>th</sup> IPCC Report – thematic areas (2013)	WBCSD 2050 Climate Themes (2011)	UNEP thematic areas (2015)	Climate-KIC 12 potential thematic areas (May 2015)	Climate-KIC priority areas and supporting elements P1-4 (Dec 2015)	UK Low Carbon Environmental Goods and Services, (2013)	England ERDF Programme I (2015)	WM Sustainability Roadmap 2020 Priorities (2010)	WM Components of Low carbon economy (2011)	WM low carbon investment prospectus local strengths (2012)
<b>A. Energy Production (35% Global GHG)</b>										
Renewable energy technologies (Climate-KIC theme)	X	X	X	X			X	X		X
Renewable energy generation, such as hydro, wave, tidal, biomass, anaerobic digestion, wind, geothermal, solar thermal, solar photovoltaic.					P1,P2	X	X		X	X
Renewable consulting.						X	X			X
Low carbon energy generation, such as: Combined Heat and Power, Carbon Capture and Storage, new nuclear.					P1	X	X			X
Smart, resilient energy infrastructure (Climate-KIC theme)	X	X		X			X	X		X
Efficient energy transmission, e.g. energy is transmitted via efficient distribution networks, with reduced transmission losses and incorporating 'smart grid' and metering technologies to allow for decentralised energy generation in homes and businesses, sometimes drawing from the energy grid and sometimes contributing to it.					P1		X		X	X
Energy management.					P1	X				X
<b>B. Agriculture, Forestry and other Land Use (24% Global GHG)</b>										
Climate smart agriculture production (Climate-KIC theme)	X	X		X						
Sustainable land use systems (Climate-KIC theme priority P2)	X	X	X	X	P2			X		
Carbon efficient and resilient agriculture, forestry and land use e.g. crops, techniques, sequestration, supply chains.					P2					
Environmental infrastructure of green and blue space, for recreation, food, health, and climate resilience.					P1, P2		X	x	x	X
<b>C. Industry (21% Global GHG)</b>										
Energy efficient production (Climate-KIC theme)	X	X		X						
Sustainable production systems (Climate-KIC theme priority P3)	X	X	X	X	P3			X		
Low carbon and resource efficient manufacturing processes, product					P3				X	X

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design and use from 'cradle to grave'.										
Resource efficient design of products and services, including industrial symbiosis.					P3					X
Waste management, water supply and wastewater treatment.					P1	X			x	X
Waste is minimised, in line with the waste hierarchy of reduction/reuse/recycling, products incorporate high levels of recycled materials and energy is generated from residual waste.					P3		X		x	
Technologies and services to reduce, collect, process, reuse and recycle materials.					P3	X			x	
New uses for disposal materials e.g. chemicals, metals, cement, plastic.					P3					
New uses of value of CO <sub>2</sub> for bio-based fuels, chemicals and products.					P3					
Environmental consultancy, environmental monitoring; marine pollution control; air pollution control, noise and vibration.						X	X		X	X
Contaminated land remediation.						X	X		X	X
Strategy advice on corporate social responsibility and environmental management system.							X			X
Low carbon workplaces - low carbon buildings, equipment, travel, use of resources and ICT.							X	X	X	
Low carbon goods and service applied to all sectors to minimise use of energy and resources, e.g. in automotives, construction, health services, retail and distribution.							X		X	
Support for low carbon jobs and skills.								X		X
<b>D. Transport and Infrastructure (14% Global GHG)</b>										
Low carbon mobility options (Climate-KIC theme)	X	X		X			X	X		X
Vehicles: highly fuel efficient vehicles, electric cars, use of alternative fuels vehicles, plug-in hybrids, rise in bikes and electric scooters.					P1	X	X		X	X
Smart transport and infrastructure systems (Climate-KIC theme)	X	X	X	X			X	X		X
Infrastructure: recharging and fuel infrastructure, local shared office space for flexible working.					P1	X	X		X	X

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Behaviour change: sustainable travel planning to increase use of public transport and smart use of other modes.					P1		X		X	X
Improved low carbon transport choices, flexible working, cycling, walking.					P1		X	X		
Car clubs.					P1					
<b>E. Buildings (6% Global GHG)</b>										
Energy efficient buildings (Climate-KIC theme)	X	X		X			X	X		X
Sustainable City Systems (Climate-KIC theme priority P1)	X	X	X	X	P1					
Low carbon building design.					P1		X		X	X
Urban Planning: standards for new and existing buildings, areas of land, and connections between them.					P1					
Energy efficiency in retrofit of existing homes and buildings.					P1		X		X	X
Materials: recycled content, insulation etc.					P1	X	X		X	
Technologies: micro-generation renewables, energy metering, efficient boilers, micro Combined Heat and Power (CHP) boilers.					P1	X	X		X	X
Services: construction, electrical, heating, plumbing, energy management and behaviour change.					P1	X	X		X	X
<b>F. Other</b>										
Measuring climate risk reduction (Climate-KIC theme)				X	X		X			X
Climate risk assessment and resilience plans.					P1					X
Climate adaptation measures – flood defences.							X			X
Tools to improve climate risk and mitigation in decision making.					P4					
Monitoring, reporting and verification of carbon emissions.					P4					
Climate finance and management (Climate-KIC theme priority P4)				X	P4	X				
Financial incentives & instruments: green bonds, carbon markets, city council fund.					P4					
Improved overall monitoring of impact of climate mitigation and adaption policies and technology.					P4					X
Use of ICT for data and monitoring.					P1					
City governance, policy, decision-making, monitoring and reporting.					P1					X

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Sustainable or green procurement.					P4			X		X
Corporate and Civic Leadership and perception and behaviour change.					P1			X		

**Table A1.2: Final research search criteria**

Ref	Heading and criteria	Example of how these relate to Climate-KIC theme priorities
<b>A.</b>	<b>Energy – renewable, low carbon, transmission</b>	
A.1	<b>Renewable energy generation</b> , such as hydro, wave, tidal, biomass, anaerobic digestion, wind, geothermal, solar thermal, solar photovoltaic.	P1 Sustainable City Systems P2 Sustainable Land Use System
A.2	<b>Low carbon energy generation</b> , such as Combined Heat and Power, Carbon Capture and Storage, new nuclear.	P1 Sustainable City Systems
A.3	<b>Energy transmission and management networks</b> , such as efficient distribution networks, ‘smart grid or metering’ technologies to allow for local two-way flow of energy and generation.	P1 Sustainable City Systems
<b>B</b>	<b>Land use – agriculture, forestry, and environmental infrastructure</b>	
B.1	<b>Carbon efficient and resilient agriculture, forestry and land use</b> , e.g. crops, techniques, sequestration, supply chains.	P2 Sustainable Land Use System
B.2	<b>Environmental infrastructure of green and blue space</b> for recreation, food, health, and climate resilience.	P1 Sustainable City Systems P2 Sustainable Land Use System
<b>C</b>	<b>Industry – design, processes, materials, specialist services</b>	
C.1	<b>Low carbon and resource efficient manufacturing processes:</b> product design and use from ‘cradle to grave’. Including environmental management systems.	P3 Sustainable Production System
C.2	<b>Technologies and services to reduce, collect, process, reuse and recycle materials</b> , including chemicals, metals, cement, plastics, use of CO <sub>2</sub> for bio-based fuels, chemicals and products, and industrial symbiosis.	P3 Sustainable Production System
C.3	<b>Environmental specialist services:</b> environmental consultancy, environmental monitoring; marine pollution control; air pollution control, noise and vibration, contaminated land, waste management, water supply and wastewater treatment.	P1 Sustainable City Systems
<b>D</b>	<b>Transport – vehicles, infrastructure, behaviour change</b>	
D.1	<b>Vehicles:</b> highly fuel-efficient vehicles, use of lightweight materials, electric cars, use of alternative fuels vehicles, plug-in hybrids, bikes and electric scooters.	P1 Sustainable City Systems

Ref	Heading and criteria	Example of how these relate to Climate-KIC theme priorities
D.2	<b>Infrastructure:</b> recharging and fuel infrastructure, local shared office space for flexible working.	P1 Sustainable City Systems
D.3	<b>Behaviour change:</b> sustainable travel planning to increase use of public transport and smart use of other modes, such as walking, cycling, use of car clubs.	P1 Sustainable City Systems
E	<b>Buildings – planning, materials, technologies, users</b>	
E.1	<b>Planning and design:</b> standards for new and existing buildings, areas of land, and connections between them.	P1 Sustainable City Systems
E.2	<b>Materials and Technologies:</b> insulation, recycled content, resilient to heat and flooding, micro-generation renewables, energy metering, efficient boilers, micro Combined Heat and Power (CHP) boilers.	P1 Sustainable City Systems
E.3	<b>Services and users:</b> construction, electrical, heating, plumbing, energy management and behaviour change.	P1 Sustainable City Systems
F	<b>Governance – leadership, finance, risk, reporting</b>	
F.1	<b>Civic and Corporate Leadership:</b> strategic training and tools for leaders of cities, local councils, business, and voluntary sector.	P1 Sustainable City Systems
F.2	<b>Financial incentives &amp; instruments:</b> green bonds, carbon markets, city council fund.	P4 Climate Finance and Management
F.3	<b>Risk management:</b> climate risk assessment and resilience plans, and decision-making tools.	P1 Sustainable City Systems P4 Climate Finance and Management
F.4	<b>Monitoring and reporting:</b> monitoring, reporting and verification of carbon emissions, impact of climate change policies and technology.	P4 Climate Finance and Management

## Appendix 2: University low carbon and climate change research strengths

There is a range of different research areas that contribute to our definition of low carbon and climate change research. We used the analysis of the recent Research Excellence Framework to identify relevant research strengths within local universities.

The 2014 **Research Excellence Framework (REF)** is a peer assessment of the quality of UK universities' research in all disciplines. The REF was undertaken by the four UK higher education funding bodies, who use the REF results to distribute research funding to universities on the basis of quality, from 2015-16 onwards.

The **impact** of research beyond academia was a new feature in this round of assessment and counted for 20 per cent of the assessment. Part of this was to submit case studies to demonstrate how university research had affected business and others.

There are 36 units of assessment used within the overall assessment e.g. Law. [The overall analysis report](#) demonstrated that some units of assessment had more of an impact on topic areas such as climate change, and environment than others (see Figure 8 in [the report on page 33](#)).

The topic areas that closely related to our research criteria were identified. These were climate change, food and nutrition, nuclear, oil and gas, water and flood management, nature conservation, transport, architecture and buildings, engineering and design and manufacturing, modelling and forecasting, community and local government, and banking and finance. We then identified the units of assessment that had scored 30 per cent or more in terms of a correlation with the produced impact case studies and where this had occurred twice or more.

This helped identify the units of assessment that had the highest correlation with having an external impact on climate change. These were:

- UOA 5 - Biological sciences
- UOA 6 - Agriculture, veterinary and food science
- UOA 7 - Earth systems and environmental sciences
- UOA 8 - Chemistry
- UOA 10 - Mathematical science
- UOA 12 - Aeronautical, mechanical, chemical and manufacturing engineering
- UOA 13 - Electrical and electronic engineering, metallurgy and materials
- UOA 14 - Civil and construction engineering

- UOA 15 - General engineering
- UOA 16 - Architecture, built environment and planning
- UOA 17 - Geography, environmental studies, archaeology

Therefore, if a university in the West Midlands has one of these type of activities this is more likely to support a range of climate change related research and impact.

The 2014 REF exercise also rated these units of assessment by quality.

<b>4*</b>	Quality that is world-leading in terms of originality, significance and rigour.
<b>3*</b>	Quality that is internationally excellent in terms of originality, significance and rigour but which falls short of the highest standards of excellence.
<b>2*</b>	Quality that is recognised internationally in terms of originality, significance and rigour.
<b>1*</b>	Quality that is recognised nationally in terms of originality, significance and rigour.
<b>Unclassified</b>	Quality that falls below the standard of nationally recognised work. Or work which does not meet the published definition of research for the purposes of this assessment.

We used the assessment to identify the international and national quality of the research within the relevant units of assessment within local universities. The website can be found here: <http://results.ref.ac.uk/Results/SelectHei>

The results are in the table below.



**Table A2.1: International and national low carbon and climate change research strengths within local universities**

West Midlands University	Research Excellence Framework (2004) Units of Assessment (UOA) that have a high correlation to impact on low carbon and climate change research and external impact.										
	UOA 5 – Biological Sciences	UOA 6 –Agriculture, veterinary and food science	UOA 7 –Earth systems and environmental sciences	UOA 8 - Chemistry	UOA 10 - Mathematical Science	UOA 12 - Aeronautical, mechanical and manufacturing engineering	UOA 13 - Electrical and electronic engineering, metallurgy and materials	UOA -14 Civil and construction engineering	UOA – 15 General engineering	UOA 16 - Architecture, built environment, and planning	UOA 17 – Geography, environmental studies, archaeology
Aston University							16/55		15/57		
University of Birmingham	32/59		13/80	11/79	15/65	14/71 = Mechanical 27/60 = Chemical	14/72 = Electrical 31/55 = Material	7/59			30/46
Birmingham City University									14/42		
Coventry University			8/44		7/74				4/56		
Harper Adams University		10/46									
Keele University			2/55		12/59				20/69		
Newman University											
Staffordshire University									2/39		

West Midlands University	Research Excellence Framework (2004) Units of Assessment (UOA) that have a high correlation to impact on low carbon and climate change research and external impact.										
	Key e.g. 32/59 = In 2004 32% of research rated 4* in terms of quality that is world-leading in terms of originality, significance and rigour. 59% of research rated 3* in terms of quality that is internationally excellent in terms of originality, significance and rigour but which falls short of the highest standards of excellence. Colour = Combined 4*&3* score. If over 75% then GREEN, if 50-74% then ORANGE, if 1-49% then YELLOW										
	UOA -5 – Biological Sciences	UOA 6 –Agriculture, veterinary and food science	UOA 7 –Earth systems and environmental sciences	UOA 8 - Chemistry	UOA 10 - Mathematical Science	UOA 12 - Aeronautical, mechanical, chemical and manufacturing engineering	UOA 13 - Electrical and electronic engineering, metallurgy and materials	UOA -14 Civil and construction engineering	UOA – 15 General engineering	UOA 16 - Architecture, built environment, and planning	UOA 17 – Geography, environmental studies, archaeology
University of Warwick	22/61	46/46		32/66	44/48				32/58		
University of Wolverhampton						1/21				5/21	
University of Worcester	6/33										2/25

### Appendix 3: Other local research centre strengths

In addition to the public funding of local universities research there is research funded by the private sector, charitable organisations and other sources such as the EU. This often follows the pattern of the public research funding. For example, our review of public funding research often revealed other private partners and funders which were captured in our analysis. However there are also a number of significant local research centre strengths that operated outside single local universities but align with local university strengths. Table A3.1 maps these against the 18 low carbon research criteria.

**Table A3.1 Other local research centre low carbon research strengths**

Ref	Heading and criteria	Energy Systems Catapult (Birmingham)	High Value Manufacturing Catapult (Warwick Manufacturing Group & Manufacturing Technology Centre)	WM Consortium for Demonstration for Intelligent Systems (Energy, Mobility, Health)	Energy Research Accelerator (Network of 6 Universities Led by Birmingham)	Motor Industry Research Association (Nuneaton)	Agriculture and Horticulture Development Board (Stoneleigh)	Additional local research strengths assessment. (Combined x = low, xx-xxxx = medium, xxxxx or higher = high)
<b>A.</b>	<b>Energy – renewable, low carbon, transmission</b>							
A.1	<b>Renewable energy generation</b> , such as hydro, wave, tidal, biomass, anaerobic digestion, wind, geothermal, solar thermal, solar photovoltaic.	X	X	X	X		X	HIGH
A.2	<b>Low carbon energy generation</b> , such as Combined Heat and Power, Carbon Capture and Storage, new nuclear.	X	X	X	XXX			HIGH
A.3	<b>Energy transmission and management networks</b> , such as efficient distribution networks, ‘smart grid or metering’ technologies to allow for local two-way flow of energy and generation.	XXX	X	XXX	XXX			HIGH
<b>B</b>	<b>Land use – agriculture, forestry, and environmental infrastructure</b>							
B.1	<b>Carbon efficient and resilient agriculture, forestry and land use</b> , e.g. crops, techniques, sequestration, supply chains.						XXX	MEDIUM
B.2	<b>Environmental infrastructure of green and blue space</b> for recreation, food, health, and climate resilience.						XXX	MEDIUM
<b>C</b>	<b>Industry – design, processes, materials, specialist services</b>							
C.1	<b>Low carbon and resource efficient</b>		XXX	X				MEDIUM

Ref	Heading and criteria	Energy Systems Catapult (Birmingham)	High Value Manufacturing Catapult (Warwick Manufacturing Group & Manufacturing Technology Centre)	WM Consortium for Demonstration for Intelligent Systems (Energy, Mobility, Health)	Energy Research Accelerator (Network of 6 Universities Led by Birmingham)	Motor Industry Research Association (Nuneaton)	Agriculture and Horticulture Development Board (Stoneleigh)	Additional local research strengths assessment. (Combined x = low, xx-xxxx = medium, xxxxx or higher = high)
	<b>manufacturing processes:</b> product design and use from 'cradle to grave'. Including environmental management systems.							
C.2	<b>Technologies and services to reduce, collect, process, reuse and recycle materials,</b> including chemicals, metals, cement, plastics, use of CO <sub>2</sub> for bio-based fuels, chemicals and products, and industrial symbiosis.		X				X	MEDIUM
C.3	<b>Environmental specialist services:</b> environmental consultancy, environmental monitoring; marine pollution control; air pollution control, noise and vibration, contaminated land, waste management, water supply and wastewater treatment.	X	X	X			X	MEDIUM
D	<b>Transport – vehicles, infrastructure, behaviour change</b>							
D.1	<b>Vehicles:</b> highly fuel-efficient vehicles, use of lightweight materials, electric cars, use of alternative fuels vehicles, plug-in hybrids, bikes and electric scooters.		XXX	XXX		XXX		HIGH
D.2	<b>Infrastructure:</b> recharging and fuel infrastructure, local shared office space for flexible working.	XXX		XXX	XX	X		HIGH
D.3	<b>Behaviour change:</b> sustainable travel planning to increase use of public transport and smart use of other modes, such as walking, cycling, use of car clubs.			XXX		X		MEDIUM
E	<b>Buildings – planning, materials, technologies, users</b>							
E.1	<b>Planning and design:</b> standards for new and existing buildings, areas of land, and connections between them.							
E.2	<b>Materials and Technologies:</b> insulation, recycled content, resilient to heat and flooding, micro-generation renewables, energy metering, efficient boilers, micro Combined Heat and Power (CHP) boilers.		X	X	X			MEDIUM

Ref	Heading and criteria	Energy Systems Catapult (Birmingham)	High Value Manufacturing Catapult (Warwick Manufacturing Group & Manufacturing Technology Centre)	WM Consortium for Demonstration for Intelligent Systems (Energy, Mobility, Health)	Energy Research Accelerator (Network of 6 Universities Led by Birmingham)	Motor Industry Research Association (Nuneaton)	Agriculture and Horticulture Development Board (Stoneleigh)	Additional local research strengths assessment. (Combined x = low, xx-xxxx = medium, xxxxx or higher = high)
E.3	<b>Services and users:</b> construction, electrical, heating, plumbing, energy management and behaviour change.	X		X	X			MEDIUM
<b>F</b>	<b>Governance – leadership, finance, risk, reporting</b>							
F.1	<b>Civic and Corporate Leadership:</b> strategic training and tools for leaders of cities, local councils, business, and voluntary sector.	X						LOW
F.2	<b>Financial incentives &amp; instruments:</b> green bonds, carbon markets, city council fund.	XX			XX			MEDIUM
F.3	<b>Risk management:</b> climate risk assessment and resilience plans, and decision-making tools.						X	LOW
F.4	<b>Monitoring and reporting:</b> monitoring, reporting and verification of carbon emissions, impact of climate change policies and technology.	X		X	X	X		MEDIUM

#### Appendix 4: Local business demand for low carbon research

We used the type and number of public research projects that involved some form of business engagement, investment or evidence of external impact as an indicator for the level of local business demand for the type of research. Although useful, the type of business sector also appeared to have an impact. For example, there are a larger number of small environmental technology and construction firms eligible for business support compared to some other sectors.

**Table A4.1 Local business demand for low carbon research**

Ref	Heading and criteria	Number of public research projects contributing to criteria	Number of KTPs, Innovation Vouchers & Impact Case Studies and (as a % of projects in criteria)	Significant local demand and engagement from business (Average of 12 or above projects)	Local businesses involved with 2 or more projects
<b>A. Energy – renewable, low carbon, transmission</b>					
A.1	<b>Renewable energy generation</b> , such as hydro, wave, tidal, biomass, anaerobic digestion, wind, geothermal, solar thermal, solar photovoltaic.	66	22 (33%)	X	Energy Transitions Ltd (3 projects) Tidal Stream Ltd (2 projects) Solar Box Ltd (2 projects)
A.2	<b>Low carbon energy generation</b> , such as Combined Heat and Power, Carbon Capture and Storage, new nuclear.	36	8 (22%)		Encraft Ltd (2) Alstom Power (2) Green engineering Ltd (2)
A.3	<b>Energy transmission and management networks</b> , such as efficient distribution networks, ‘smart grid or metering’ technologies to allow for local two-way flow of energy and generation.	38	8 (21%)		Encraft Ltd (3) Alstom Power (2) Anvil Semi Conductors Ltd (2) Future Energy Ltd (2) Oswald Consultancy (2)
<b>B Land use – agriculture, forestry, and environmental infrastructure</b>					
B.1	<b>Carbon efficient and resilient agriculture, forestry and land use</b> , e.g. crops, techniques, sequestration, supply chains.	58	15 (25%)	X	SERE-Tech Innovation Ltd (3) JLR (2) Saturn Bioponics Ltd (2) Tarmac Ltd (2)
B.2	<b>Environmental infrastructure of green and blue space</b> for recreation, food, health, and climate resilience.	35	8 (23%)		JLR (2)
<b>C Industry – design, processes, materials, specialist services</b>					
C.1	<b>Low carbon and resource efficient manufacturing processes</b> : product design and use from ‘cradle to grave’. Including environmental management systems.	80	19 (24%)	X	JLR (9) Aeristone Tech Ltd (4) Alliance Software (2) SERE-tech innovation (2) Fusion Systems Ltd (2) Carillion Energy Systems (2) Lucideon (2)

Ref	Heading and criteria	Number of public research projects contributing to criteria	Number of KTPs, Innovation Vouchers & Impact Case Studies and (as a % of projects in criteria)	Significant local demand and engagement from business (Average of 12 or above projects)	Local businesses involved with 2 or more projects
					Lontra Ltd (2)
C.2	<b>Technologies and services to reduce, collect, process, reuse and recycle materials</b> , including chemicals, metals, cement, plastics, use of CO <sub>2</sub> for bio-based fuels, chemicals and products, and industrial symbiosis.	51	16 (31%)	X	Env-Aqua Solutions Ltd (2) JLR (2) SERE-tech innovation (2)
C.3	<b>Environmental specialist services</b> : environmental consultancy, environmental monitoring; marine pollution control; air pollution control, noise and vibration, contaminated land, waste management, water supply and wastewater treatment.	51	23 (45%)	X	Middlemarch environmental (2)
<b>D</b>	<b>Transport – vehicles, infrastructure, behaviour change</b>				
D.1	<b>Vehicles</b> : highly fuel-efficient vehicles, use of lightweight materials, electric cars, use of alternative fuels vehicles, plug-in hybrids, bikes and electric scooters.	67	10 (15%)		JLR (17) GKN Driveline (5) Aeristech (5) Fusion Innovation Ltd (4) Antonov Technologies (2) Anvil Semi Conductors (2) JCB Services (2)
D.2	<b>Infrastructure</b> : recharging and fuel infrastructure, local shared office space for flexible working.	19	5 (26%)		JLR (2) Anvil Semi Conductors (2)
D.3	<b>Behaviour change</b> : sustainable travel planning to increase use of public transport and smart use of other modes, such as walking, cycling, use of car clubs.	18	3 (17%)		None
<b>E</b>	<b>Buildings – planning, materials, technologies, users</b>				
E.1	<b>Planning and design</b> : standards for new and existing buildings, areas of land, and connections between them.	12	7 (58%)		N/A
E.2	<b>Materials and Technologies</b> : insulation, recycled content, resilient to heat and flooding, micro-generation renewables, energy metering, efficient boilers, micro Combined Heat and Power (CHP) boilers.	131	28 (21%)	X	JLR (13) Areistech Ltd (5) Anvil Semi conductors (4) GKN (3) Fusion innovation Ltd (2) Fusion systems Ltd (2) Integrated Systems Technologies (2) Lontra Ltd (2) Saturn Bioponics (2)
E.3	<b>Services and users</b> : construction, electrical, heating, plumbing, energy management and behaviour change.	27	13 (48%)	X	Encraft (2)

Ref	Heading and criteria	Number of public research projects contributing to criteria	Number of KTPs, Innovation Vouchers & Impact Case Studies and (as a % of projects in criteria)	Significant local demand and engagement from business (Average of 12 or above projects)	Local businesses involved with 2 or more projects
F	<b>Governance – leadership, finance, risk, reporting</b>				
F.1	<b>Civic and Corporate Leadership:</b> strategic training and tools for leaders of cities, local councils, business, and voluntary sector.	8	3 (38%)		n/a
F.2	<b>Financial incentives &amp; instruments:</b> green bonds, carbon markets, city council fund.	8	0 (0%)		Encraft (2)
F.3	<b>Risk management:</b> climate risk assessment and resilience plans, and decision-making tools.	25	10 (40%)		Birmingham City Council (2) Hydro-Logic Ltd (3)
F.4	<b>Monitoring and reporting:</b> monitoring, reporting and verification of carbon emissions, impact of climate change policies and technology.	14	10 (71%)		n/a



## **Appendix 5: Local low carbon goods and services businesses alignment with local research strengths**

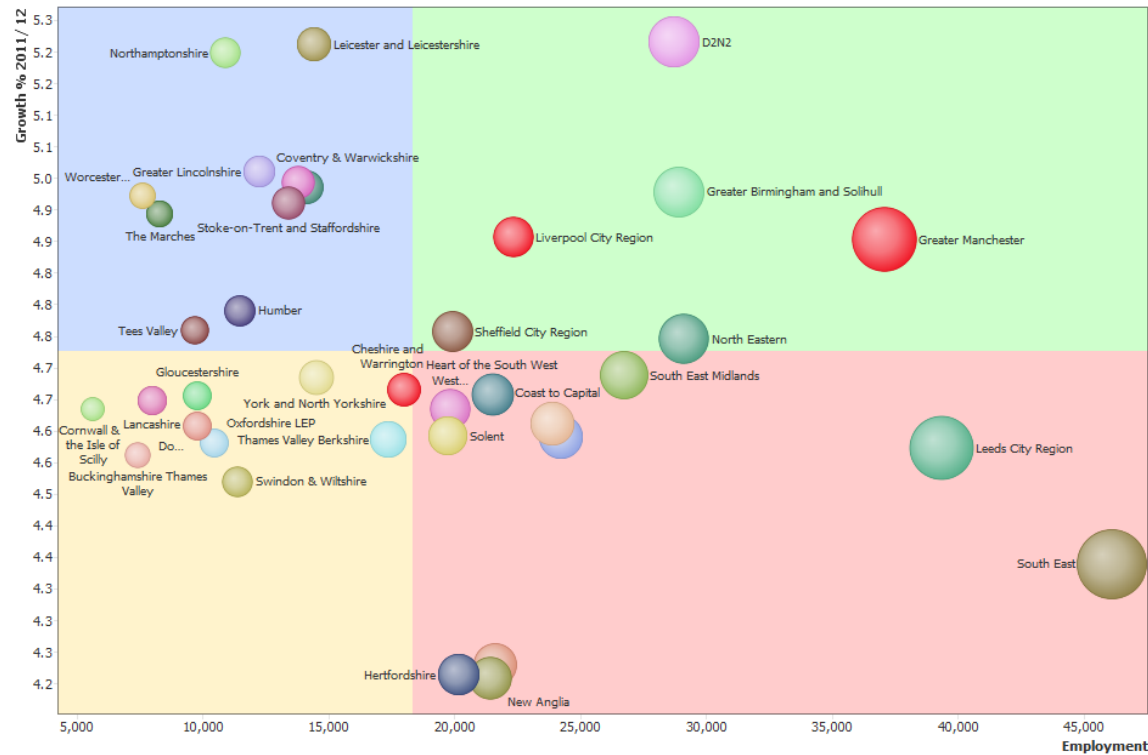
There is an ongoing national attempt to measure the size and performance of the UK low carbon economy and provide regional breakdowns. This is challenging as using a broader definition to find low carbon activity 'hidden' with traditional business classification is difficult. For example, how do you measure the proportion within a traditional automotive company that is focused on low carbon technology? Also the changing definitions in studies make trend comparison difficult. For example, the latest research published in 2015 only considered products and technologies delivering a "step change" in carbon performance rather than economic benefits. SWM is currently investigating the merits of expanding the recent low carbon good analysis for the Birmingham LEP energy study in early 2016 to the rest of the WMCA area.

Tables A5.1 and A5.2 illustrate the results of the BIS 2011/12 research published in July 2013 by BIS. The research indicated that of the six West Midlands LEAs, five were experiencing nationally significant high growth in sales (Worcester, The Marches, Black Country, Stoke and Staffordshire, Coventry and Warwickshire) and one (Birmingham and Solihull) was experiencing nationally significant growth in sales and employment.

Table A5.3 illustrates the results of the BIS 2012/13 research published in 2015 by BIS. As this used a narrower definition of the low carbon sector, the estimated employment covered is half of the previous research, although all the sectors monitored still show substantial growth.

Where possible we have used the two research reports to compile some indicator of growth and demand, and produced an assessment on how significant the sub-sectors are for the West Midlands based on rate of growth and employment share. Due to recent policy and legislation changes in 2015, some sectors, such as solar PV and construction, will no longer be so strong.

**Table A5.1 Weighting of LEPs (minus London) on low carbon sales growth and employment in 2011/12. (Extract from BIS 2013 research)**



**Table A5.2 LEP Low Carbon Sales and Employment employment in 2011/12. (Based on data from BIS 2013 research)**

LEP	Sales £m	Companies	Employment
Black Country	1,870.73	770	14,106
Coventry and Warwickshire	1,803.06	756	13,758
Greater Birmingham and Solihull	3,833.24	1580	28,899
Stoke on Trent and Staffordshire	1,777.65	730	13,387
The Marches	1,097.04	453	8,279
Worcestershire	1,004.94	411	7,569
<b>Total</b>	<b>14,055.51</b>	<b>4700</b>	<b>85,998</b>

**Table A5.3 Strength of West Midlands Low Carbon Goods and Services Sector (Based on data from BIS 2013 -2015 research)**

Low Carbon and Environmental Goods and Services Sector	Business investment by companies in UK £m (excluding supply chains) 2013	Jobs by sector in UK (including supply chains) 2013	Jobs growth by sector in UK (including supply chains) 2010-13	Turnover by sector in UK £m (including supply chains) 2013	Turnover change by sector in UK (including supply chains) 2010-13	GVA by sector in UK £m (including supply chains) 2013	GVA growth by sector in UK £m (including supply chains) 2010-13 (a)	UK demand not being met locally- value of imports 2012 £m. *- where same figure used across several sectors	Global demand – Value of UK exports 2012 £m*- where same figure used across several sectors	Employment in WM in companies and supply chain 2013	Ranking of WM out of 9 English regions including London (1 is highest) 2013	Share of WM employment within England including London 2013 (b)	Significance for WM  GVA growth (a) + WM employment share (b)  21%> = High, 11--20%=Medium 0-10% = Low
Onshore wind	240	19000	10%	6300	5.3%	1700	11.5%	736*	1718*	1,300	(4/9)	10%	HIGH
Offshore wind	170	13700	8%	3500	2.5%	1000	16.9%	736*	1718*	1,000	(5/9)	9%	HIGH
Nuclear Energy	830	59000	3%	12100	6%	3500	2.8%	81	194	400	(9/9)	1%	LOW
Hydroelectric energy	30	7400	2.9%	1900	4.5%	600	-2.1%	41	71	100	(6/9)	2%	LOW
Marine	30	3100	1.5%	400	5.5%	100	13.3%	5	9	100	(5/9)	5%	MEDIUM
Solar PV	150	34400	20.8%	8400	11.9%	3300	6.3%	689	1391	4,100	(2/9)	14%	HIGH
Energy generation from waste and biomass	420	21900	2.8%	4100	3.2%	1200	-1.2%	113	180	1,100	(8/9)	5%	LOW
Carbon capture and storage	20	4100	1.2%	600	-3.2%	200	-7.3%	63	71	300	(3/9)	6%	LOW
Biomass equipment	110	11700	2.2%	2500	6.5%	1000	8.1%	481	752	1,300	(3/9)	13%	HIGH
Geothermal	10	3500	8.5%	800	12%	300	11%	720	1043	200	(4/9)	7%	MEDIUM
Heat pumps	60	22700	2.9%	3100	4.5%	1000	1.5%	103*	1484*	2,200	(4/9)	12%	MEDIUM
Solar thermal	10	5200	4%	800	3.4%	300	3.6%	103*	1484*	500	(4/9)	13%	MEDIUM
Heat networks	10	1200	3.8%	200	6.4%	100	6.9%	103*	1484*	100	(3/9)	11%	MEDIUM
Energy-efficient	40	14600	0.6%	3500	-2.5%	1600	-0.9%	835*	1484*	1,000	(4/9)	8%	LOW

Low Carbon and Environmental Goods and Services Sector	Business Investment by companies in UK £m (excluding supply chains) 2013	Jobs by sector in UK (including supply chains) 2013	Jobs growth by sector in UK (including supply chains) 2010-13	Turnover by sector in UK £m(including supply chains) 2013	Turnover change by sector in UK (including supply chains) 2010-13	GVA by sector in UK £m (including supply chains) 2013	GVA growth by sector in UK £m (including supply chains) 2010-13 (a)	UK demand not being met locally- value of imports 2012 £m. *- where same figure used across several sectors	Global demand – Value of UK exports 2012 £m*- where same figure used across several sectors	Employment in WM in companies and supply chain 2013	Ranking of WM out of 9 English regions including London (1 is highest) 2013	Share of WM employment within England including London 2013 (b)	Significance for WM  GVA growth (a) + WM employment share (b)  21%> = High, 11--20%=Medium 0-10% = Low
lighting													
Insulation	50	36000	3.2%	5500	4.7%	2000	3.9%	835*	1484*	3,900	(3/9)	12%	MEDIUM
Energy-efficient windows and doors	20	17500	1.3%	2800	-3.5%	1,200	-5.5%	835*	1484*	5,200	(1/9)	35%	HIGH
Heat recovery and ventilation	20	9400	-0.4%	1500	-0.4%	700	2.1%	835*	1484*	1,000	(4/9)	13%	MEDIUM
Energy controls and control systems	100	12800	-4.9%	2200	5.1%	1,100	10.6%	205	356	700	(3/9)	6%	MEDIUM
Sustainable architecture and buildings	20	4000	0.8%	900	0.8%	700	2.7%	835*	1484*	500	(3/6)	14%	MEDIUM
Low carbon advisory services	230	22600	0.1%	2800	3.9%	1400	1.6%	121 Air pollution, 68 Renewable energy consultancy 59 Contaminated Land, 49 Environmental consultancy, pollution controls	175 Air pollution, 68 Renewable energy consultancy 95 Contaminated Land, 102 Environmental consultancy, pollution controls	1,100	(8/9)	6%	LOW

Low Carbon and Environmental Goods and Services Sector	Business Investment by companies in UK £m (excluding supply chains) 2013	Jobs by sector in UK (including supply chains) 2013	Jobs growth by sector in UK (including supply chains) 2010-13	Turnover by sector in UK £m(including supply chains) 2013	Turnover change by sector in UK (including supply chains) 2010-13	GVA by sector in UK £m (including supply chains) 2013	GVA growth by sector in UK £m (including supply chains) 2010-13 (a)	UK demand not being met locally- value of imports 2012 £m. *- where same figure used across several sectors	Global demand – Value of UK exports 2012 £m*- where same figure used across several sectors	Employment in WM in companies and supply chain 2013	Ranking of WM out of 9 English regions including London (1 is highest) 2013	Share of WM employment within England including London 2013 (b)	Significance for WM  GVA growth (a) + WM employment share (b)  21%> = High, 11--20%=Medium 0-10% = Low
Low carbon finance	10	5400	-0.8%	900	0.6%	400	-1.6%	101	169	700	(3/9)	14%	MEDIUM
Recycling - recovery and reprocessing of materials from waste	800	93500	3.2%	21800	5.3%	6200	4%	279 Recycling 926 Waste water treatment	605 Recycling 1263 Waste water treatment	9,900	(3/9)	12%	MEDIUM
Alternative fuels	120	19800	5%	26100	21.9%	13600	24.4%	740	1266	1,700	(3/9)	11%	HIGH
Low emission vehicles	80	18100	3.9%	8800	5.3%	1700	8.7%	387	662	2,700	(2/9)	17%	HIGH
Totals	3,580	460,600	3.8%	121,700	7.6%	44,900	8.7%	7035	12,211	Total WM employment 41,100	Average ranking = 4	Average WM share = 11%	N/A

## **Appendix 6: Wider local businesses opportunities and alignment with local research strengths**

The local low carbon goods and services sector only form part of the wider local business opportunities. For example, the application of specialist low carbon services, such as energy management, to other businesses such as manufacturing, often have a more significant impact in terms of productivity and carbon reduction than that of the growth of the energy management company.

The West Midlands was the first region in the UK to produce a low carbon regional economic strategy 'connecting to success' that had a clear evidence base underpinning sub-regional action to improve productivity and reduce carbon emissions. Subsequently, the region has a rich evidence base to inform low carbon policy.

### **The Low Carbon Economy in the West Midlands Research Programme (West Midlands Regional Observatory 2010)**

SWM chaired a research programme run by the WMRO for the region and the city region initiative to build on the 'connecting to success' evidence base. This included region-wide work, workshops, local authority profiles, and sub-regional analysis based on the city region initiative in 2010, similar to the WMCA in 2016.

This work was recognised as good practice by government and subsequently replicated in several other regions in the UK and Europe. Although the impact of the recession on the economy will have changed some of the figures, the overall analysis and recommendations for the local economic geography is still valid in 2016.

The research aimed to develop a better understanding of the risks and opportunities the low carbon economy can deliver for the West Midlands. A low carbon economy was defined as 'one where businesses deliver products and services of increasing value while reducing their overall level of carbon emissions'. Therefore, it took a holistic view of the whole economy rather than the narrow low carbon or environmental goods and services sector.

### ***Impact of Carbon Legislation and Energy prices in the West Midlands***

The research reviewed the potential impact that carbon legislation and energy prices would have on businesses and employment in the region. The findings included:

- Sectors that contribute a high proportion of the regional economic productivity, such as financial and professional services, have low exposure to carbon legislation and energy prices.
- The sectors more vulnerable to carbon legislation in the region are health and social work, transport and communications, education and construction. Mainly high energy-intensive industries.
- Businesses in these sectors are already responding to the low carbon agenda in their own efforts by improving their energy and resource efficiency.
- Support measures should also be implemented at regional and local level to help mitigation against potential risks of legislation, energy or changing markets.

The impact varies across local authority area – see the extract from main report below.

Table 4.2 - Proportion of employees & businesses in high risk sectors (according to operations and products/services)

LA	% of Employees at High Risk	LA	% of Businesses at High Risk
Stoke-on-Trent	46.0%	Staffordshire	27.4%
Wolverhampton	42.1%	Stoke-on-Trent	26.8%
Solihull	40.7%	Herefordshire	26.6%
Coventry	39.8%	Shropshire	26.3%
Shropshire	39.6%	Walsall	25.7%
Staffordshire	38.6%	Dudley	24.8%
Sandwell	38.1%	Sandwell	24.1%
West Midlands	37.1%	West Midlands	24.0%
Birmingham	36.3%	Telford and Wrekin	23.7%
Warwickshire	35.1%	Coventry	22.9%
Walsall	34.7%	Solihull	22.8%
Herefordshire	34.2%	Warwickshire	22.6%
Worcestershire	33.5%	Worcestershire	22.6%
Dudley	32.9%	Wolverhampton	22.3%
Telford and Wrekin	32.5%	Birmingham	21.1%

Source: Data provided by WMRO (ABI data), 2007

The West Midlands average is highlighted at the appropriate point in the table.

### ***Low Carbon Economic Opportunities for the West Midlands***

The research identified businesses can benefit from the low carbon economy in two ways:

- **Diversification** – developing new low carbon products
- **Decarbonising** – becoming more efficient in their current processes or delivering their current products more efficiently. For example, using fewer resources, producing less waste or using less energy.

The low carbon economy can deliver opportunities across a wide range of business sectors, not just to those seen as being in the 'traditionally' environmental technologies sector.

The sectors identified as providing the greatest low carbon opportunities in the region were:

- Non-metallic mineral goods
- Automotive and transport equipment
- Metals and metal products
- Construction
- Environmental goods and services
- Food and beverages
- Transport, storage and communications
- Public services

These sectors are present across all local authorities in the region, although concentrations vary - see extract from report below.



Table 4.6 - Summary of Opportunities within Sub-Regions within West Midlands economy

	Birmingham	Sandwell	Walsall	Dudley	Coventry	Solihull	Wolverhampton	Staffordshire	Worcestershire	Warwickshire	Herefordshire	Shropshire	Stoke on Trent	Telford & Wrekin
Manufacture of non-metallic mineral goods	L	L	L	L	L	L	L	H	L	L	L	L	L	L
Manufacture of automotive and transport equipment	H	L	L	L	H	L	L	H	L	L	L	H	M	H
Manufacture of metals, fabricated metal products and electrical equipment	H	H	H	L	L	L	L	H	H	L	L	L	L	L
Construction	H	L	L	L	L	L	H	H	H	H	M	H	H	H
Manufacture of food and beverages	L	M	L	L	L	L	L	M	L	L	M	M	L	L
Environmental goods and services <sup>5</sup>	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Transport, storage and communications	H	L	L	L	H	L	L	H	L	H	L	H	L	H
Public Services	H	H	H	H	H	H	H	H	L	L	L	H	L	H

**High (H)** – Industry has a *highly significant* presence in the sub-region (>2% employees)

**Medium (M)** – Industry has a *significant* presence in the sub-region (1 – 2% employees or local specialism (LQ analysis))

**Low (L)** – Industry has a *minor* presence in the sub-region (<1% employees)

Further analysis for the sub-regions of the Black Country, Birmingham, Solihull, Coventry, and Telford and Wrekin revealed a more detailed set of local business sectors where the low carbon economy could help grow or stabilise jobs in 2010. These were:

- Low carbon design for construction
- Low carbon renovation of Local Authority (LA) council stock and wider city housing
- Manufacturing of low carbon transport
- Low carbon vehicle design
- Development and use of alternative fuels
- Procurement of low carbon services / products for the public sector
- Low carbon education
- Use of planning to support development of the low carbon economy

The research identifies that the following sectors have the potential for increased employment:

- Environmental goods and services
- Manufacture of food and drink
- Manufacture of motor vehicles and transport
- Manufacture of non-metallic mineral goods
- Public services
- Transport, storage and communication

The following table summarise the opportunities and its impact on jobs across each of the Local Authorities included in the research.

Sector	<div style="border: 1px solid black; padding: 2px; display: inline-block; width: 20px; height: 20px; background-color: #92d050; text-align: center; line-height: 20px;">+</div> <div style="border: 1px solid black; padding: 2px; display: inline-block; width: 20px; height: 20px; background-color: #add8e6; text-align: center; line-height: 20px;">=</div>	Opportunity Increase in jobs	Birmingham	Coventry	Dudley	Sandwell	Solihull	Telford & Wrekin	Walsall	Wolverhampton
		Stabilise jobs								
<b>Construction</b>		Low carbon design and construction for buildings	+	+	=	=	+		=	+
		Use of low carbon design for civil engineering	+	=	=	=	+		=	=
		Reuse of materials and use of recycled materials	=		=	=	=		=	=
		Low carbon renovation of LA council stock and wider city housing	+	+	+	+	+	+	+	+
		Provision of low carbon services and trades	+	+	+		+	=	+	
		Provision of low carbon equipment		+				=		
		Off-site construction of buildings			+	+				
		Use of low carbon materials and equipment	=							=
<b>Manufacture automotive &amp; transport equipment</b>		Manufacturing of low carbon transport equipment	+	+	=	=	+	=	=	
		Low carbon vehicle design	+	+		=	+	=	=	=
		Development of alternative fuels and associated infrastructure	+	+			+	=	=	
<b>Manufacture non-metallic mineral goods</b>		Low carbon design, construction methods and materials	=			=		=		
		Cost savings by use of more efficient vehicles and equipment	=		=	=	=	=	=	=
		Use and development of low carbon products	+		=		=		+	=
<b>Public Services</b>		Ability to procure low carbon services and products for the sector	+	+	+	+	+	+	+	+
		'Low Carbon' Education	+	+	+	+	=	=	=	+
		Use of planning to support development of LCE transport, energy, waste, etc.	+	+	+	+	+	+	+	+
		Defence sector support and advice to reduce carbon emissions						+		

Sector	<div style="border: 1px solid black; padding: 2px; display: inline-block; width: 20px; height: 15px; background-color: #92d050; text-align: center; line-height: 15px;">+</div> <div style="border: 1px solid black; padding: 2px; display: inline-block; width: 20px; height: 15px; background-color: #add8e6; text-align: center; line-height: 15px;">=</div>	Opportunity Increase in jobs	Birmingham	Coventry	Dudley	Sandwell	Solihull	Telford & Wrekin	Walsall	Wolverhampton
		Stabilise jobs								
<b>Manufacture metals &amp; fabricated metal products and electrical equipment</b>		Low carbon processes	=	=	+	+	=	=	=	+
		Production of equipment for low carbon energy systems and vehicles	+		+	+			+	+
<b>Transport, storage and communications</b>		Sustainable logistics for inbound and outbound distribution transports and increasing the use of rail freight	+		=	+		+	+	+
		Shared loading for cargo					=			
		Development / use of alternative fuels and associated infrastructure	+		+	+	+	+	+	+
		Low carbon travel services					=			
<b>Environmental goods and services</b>		Use of low carbon vehicles and premises	=		=	=	=		=	=
		Increase of non-metals waste recycling						+		+
		Provision of specialist advice to all sectors on low carbon	+	+			+	+		=
		Continued establishment of metal waste and scrap sector			+	+			+	+
		Development of electric motor and generators							+	+
<b>Manufacture of food and beverages</b>		Development of low carbon community energy companies / schemes	+	+	+	+	+	+	+	+
		Commercial opportunity from use of food waste	+	+	+	+		+	+	+
		Increased recycling of packaging from food and drink products				=	=		+	
		Decarbonisation of processes to retain cost effectiveness			=	=	=	=	=	=
	Low carbon products				=		=		=	

## Appendix 7: Impact of future drivers on the demand for local low carbon research

In 2015 SWM, working with the Government Office of Science and many other local partners, updated the previous future drivers of the West Midlands research. The result was '[The Future we made: Birmingham and West Midlands Futures Toolkit 2020-2060](#)'. The 12 future drivers were used to assess whether the demand for the different areas of low carbon research were likely to increase in the future. The summary results are in the table below.

**Table A7.1 Impact of West Midlands future drivers on demand for local low carbon research**

Ref	Heading and criteria	Population Changes	Changing workforce, skills and working practices on business	Impact of lifestyles and environment on health	Increased demand for more regional or local powers and governance	Widening inequality and inclusion gap	Knowledge economy and networked world	Accelerated change from new technology opportunities for business	Globalisation of markets and competition on business	Increased stress on transport infrastructure for public services and business	Pressure for climate change adaptation	Pressure on natural resources	Emphasis on lower carbon energy supply, security and cost for public services, business, and communities	Increased pressure on natural resources	Overall Future Demand for Research  Occurrence of HIGH 1-4=Med 5-8=High 9-12=Very High
<b>A.</b>	<b>Energy – renewable, low carbon, transmission</b>														
A.1	<b>Renewable energy generation</b> , such as hydro, wave, tidal, biomass, anaerobic digestion, wind, geothermal, solar thermal, solar photovoltaic.	MED		HIGH		MED	HIGH	HIGH	HIGH			HIGH	HIGH		<b>6/12 HIGH</b>
A.2	<b>Low carbon energy generation</b> , such as Combined Heat and Power, Carbon Capture and Storage, new nuclear.	MED		HIGH			MED	HIGH	HIGH			MED	MED		<b>3/6 MEDIUM</b>
A.3	<b>Energy transmission and management networks</b> , such as efficient distribution networks, 'smart grid or metering' technologies to allow for local two-way flow of energy and generation.	HIGH	HIGH	MED	HIGH	MED	HIGH	HIGH	HIGH	HIGH	HIGH		HIGH		<b>9/12 VERY HIGH</b>
<b>B</b>	<b>Land use – agriculture, forestry, and environmental infrastructure</b>														
B.1	<b>Carbon efficient and resilient agriculture, forestry and land use</b> , e.g. crops, techniques, sequestration, supply chains.	HIGH	HIGH	HIGH	MED	MED	MED	HIGH	HIGH	MED	HIGH	HIGH	MED		<b>7/12 HIGH</b>

Ref	Heading and criteria		Population Changes	Changing workforce, skills and working practices on business	Impact of lifestyles and environment on health	Increased demand for more regional or local powers and governance	Widening inequality and inclusion gap	Knowledge economy and networked world	Accelerated change from new technology opportunities for business	Globalisation of markets and competition on business	Increased stress on transport infrastructure for public services and business	Pressure for climate change adaptation	Pressure on natural resources	Emphasis on lower carbon energy supply, security and cost for public services, business, and communities	Increased pressure on natural resources	Overall Future Demand for Research  Occurrence of HIGH 1-4=Med 5-8=High 9-12=Very High
B.2	<b>Environmental infrastructure of green and blue space</b> for recreation, food, health, and climate resilience.	HIGH		HIGH		HIGH					MED	HIGH	HIGH			5/6 HIGH
<b>C</b>	<b>Industry – design, processes, materials, specialist services</b>															
C.1	<b>Low carbon and resource efficient manufacturing processes:</b> product design and use from ‘cradle to grave’. Including environmental management systems.		HIGH	HIGH	MED		HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH		9/12 VERY HIGH
C.2	<b>Technologies and services to reduce, collect, process, reuse and recycle materials,</b> including chemicals, metals, cement, plastics, use of CO <sub>2</sub> for bio-based fuels, chemicals and products, and industrial symbiosis.		HIGH		MED	MED	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	MED		7/9 HIGH
C.3	<b>Environmental specialist services:</b> environmental consultancy, environmental monitoring; marine pollution control; air pollution control, noise and vibration, contaminated land, waste management, water supply and wastewater treatment.		HIGH	HIGH			HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH		9/12 VERY HIGH
<b>D</b>	<b>Transport – vehicles, infrastructure, behaviour change</b>															
D.1	<b>Vehicles:</b> highly fuel-efficient vehicles, use of lightweight materials, electric cars, use of alternative fuels vehicles, plug-in hybrids, bikes and electric scooters.		HIGH	HIGH			HIGH	HIGH	HIGH	HIGH				HIGH		7/9 HIGH
D.2	<b>Infrastructure:</b> recharging and fuel infrastructure, local shared office space for flexible working.		HIGH	HIGH	MED		HIGH	HIGH	HIGH	HIGH				HIGH		7/9 HIGH
D.3	<b>Behaviour change:</b> sustainable travel planning to increase use of public transport	HIGH	HIGH	HIGH	HIGH	MED	HIGH	HIGH			HIGH	HIGH				8/12 HIGH

Ref	Heading and criteria	Population Changes	Changing workforce, skills and working practices on business	Impact of lifestyles and environment on health	Increased demand for more regional or local powers and governance	Widening inequality and inclusion gap	Knowledge economy and networked world	Accelerated change from new technology opportunities for business	Globalisation of markets and competition on business	Increased stress on transport infrastructure for public services and business	Pressure for climate change adaptation	Pressure on natural resources	Emphasis on lower carbon energy supply, security and cost for public services, business, and communities Increased pressure on natural resources	Overall Future Demand for Research  Occurrence of HIGH 1-4=Med 5-8=High 9-12=Very High
	and smart use of other modes, such as walking, cycling, use of car clubs.													
E	<b>Buildings – planning, materials, technologies, users</b>													
E.1	<b>Planning and design:</b> standards for new and existing buildings, areas of land, and connections between them.	HIGH	HIGH	HIGH	HIGH	HIGH	MED	HIGH	MED	HIGH	HIGH	HIGH	HIGH	10/12 VERY HIGH
E.2	<b>Materials and Technologies:</b> insulation, recycled content, resilient to heat and flooding, micro-generation renewables, energy metering, efficient boilers, micro Combined Heat and Power (CHP) boilers.	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH		HIGH	HIGH	HIGH	11/12 VERY HIGH
E.3	<b>Services and users:</b> construction, electrical, heating, plumbing, energy management and behaviour change.	HIGH	HIGH	HIGH	MED	HIGH	HIGH	HIGH	HIGH		HIGH	MED	HIGH	9/12 VERY HIGH
F	<b>Governance – leadership, finance, risk, reporting</b>													
F.1	<b>Civic and Corporate Leadership:</b> strategic training and tools for leaders of cities, local councils, business, and voluntary sector.	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	12/12 VERY HIGH
F.2	<b>Financial incentives &amp; instruments:</b> green bonds, carbon markets, city council fund.	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	12/12 VERY HIGH
F.3	<b>Risk management:</b> climate risk assessment and resilience plans, and decision-making tools.	HIGH	HIGH	HIGH	HIGH	HIGH				HIGH	HIGH	HIGH	HIGH	9/12 VERY HIGH
F.4	<b>Monitoring and reporting:</b> monitoring, reporting and verification of carbon emissions, impact of climate change policies and technology.		MED	HIGH	MED	MED	HIGH		MED		HIGH	HIGH	MED	4/12 MEDIUM

END