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UK COMMISSION FOR EMPLOYMENT AND SKILLS

Strategic Skills Needs in the Low Carbon Energy Generation Sector

A report for the National Strategic Skills Audit for England 2010

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Foreword

Launched on 1st April 2008, the UK Commission for Employment and Skills is a key recommendation in Lord Leitch's 2006 review of skills Prosperity for All in the Global Economy: World Class Skills. The UK Commission aims to raise UK prosperity and opportunity by improving employment and skills. Its ambition is to benefit individuals, employers, government and society by providing independent advice to the highest levels of the UK Government and Devolved Administrations on how improved employment and skills systems can help the UK become a world class leader in productivity, in employment and in having a fair and inclusive society.

Research and policy analysis plays a fundamental role in the work of the UK Commission and is central to its advisory function. In fulfilling this role, the Research and Policy Directorate of the UK Commission is charged with delivering a number of the core activities of the UK Commission and has a crucial role to play in:

- Assessing progress towards making the UK a world-class leader in employment and skills by 2020;
- Advising Ministers on the strategies and policies needed to increase employment, skills and productivity;
- Examining how employment and skills services can be improved to increase employment retention and progression, skills and productivities;
- Promoting employer investment in people and the better use of skills.

We will produce research of the highest quality to provide an authoritative evidence base; we will review best practice and offer policy innovations to the system; we will undertake international benchmarking and analysis and we will draw on panels of experts, in the UK and internationally, to inform our analysis.

Sharing the findings of our research and policy analysis and engaging with our audience is very important to the UK Commission. Our Evidence Reports are our chief means of reporting our detailed analytical work. Our other products include Summaries of these reports; Briefing Papers; Thinkpieces, seminars and an annual Research and Policy Convention. All our outputs are accessible in the Research and Policy pages at www.ukces.org.uk

This report was commissioned by the UK Commission to contribute to the evidence base for the National Strategic Skills Audit for England 2010. A further two reports were commissioned to identify the strategic skills needs in the Bio-medical and Financial Services sectors and a fourth, Horizon Scanning and Scenario Building: Scenarios for Skills 2020, investigated the potential implications for skills of future national and global scenarios. We hope you find the report useful and informative in building the evidence we need to achieve a more prosperous and inclusive society.

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AND POLICY

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Introduction

The aim of this study is to provide an assessment of the skills needs in the low carbon energy generation sector to 2020 in support of the National Strategic Skills Audit for England 2010, undertaken by the UK Commission for Employment and Skills. For the purpose of this exercise the sector comprises wind, marine, microgeneration, carbon capture and storage, and nuclear sub sectors. This report presents the findings of the assessment which, while discussed in further detail below, are that:

- The sector is currently relatively small scale in terms of direct jobs, but has a great deal of potential for growth;
- Current and projected shortages of skills in the sector, particularly in relation to STEM subjects (Science, Technology, Engineering and Mathematics), means that the low carbon sector will need to compete for STEM graduates with industry as a whole;
- Wind and nuclear will be the most important sectors in driving growth between now and 2020, but barriers such as access to financing and planning are significant;
- Marine and carbon capture and storage are unlikely to contribute materially to employment in the period to 2020, but are more likely to come to fruition post-2020;
- The extent to which new jobs will necessarily be generated throughout the value chain in the medium-term varies by sub sector. In the wind and nuclear sectors, it is likely that there will be relatively large numbers of jobs created in construction and installation, given the ambitious plans for installing new capacity to 2020. However, there is less likelihood of significant numbers of manufacturing jobs;
- There is considerable potential to exploit skills transfer from other industries such as the upstream oil and gas industry to low carbon energy generation, which will also help to minimise the potential impact of a decline in employment within carbon intensive energy generation or nuclear power;
- There is no clear evidence that technical jobs in the sector will change markedly over the next decade – rather, differences are likely to emerge by degree;
- There is a lack of official national statistics on the low carbon sector and the on-going debate over what constitutes a 'green job'; and
- Government will play a critical role in how it seeks to stimulate demand with incentives, but also in how it can remove barriers that could otherwise hinder growth.

The impetus for the Audit came from the policy document, New Industry, New Jobs, published by the then Department for Business, Enterprise and Regulatory Reform in April 2009. New Industries, New Jobs identified low carbon as one of six priority sectors for development. This document was followed in July 2009 by the Low Carbon Transition Strategy which noted that the global market for low carbon and environmental goods and services (LCEGS) was already worth £3 trillion in 2007/08 and that the UK is in a strong position to develop its base in this sector. The latter strategy also sets out the main planks of a more activist approach to developing skills in low carbon as a whole. Given the potential importance of this sector to the economy, this report provides a timely response to the current debate into the UK's strategic skills needs.

Our study is part of a wider exercise designed to contribute towards the UK Commission's overall response to strategic skills, the National Strategic Skills Audit for England 2010. This Audit, which is supporting current Government-led developments around industrial and skills activism, is comprised of a number of strands, including:

- A national assessment: to provide a strategic national overview and assessment of immediate and emerging priority skills needs in both existing and emerging industries. This will also include a regional assessment, providing a consistent and comparable skills assessment across the UK;

- Priority sectors assessments: to provide an assessment of the skills needs of key, selected priority sectors; and

- Horizon scanning: to provide an assessment of what the future may hold by scanning the horizon, exploring important emerging issues and developments and bridging policy-making in the short and long term.

Scope of research

The low carbon energy generation sector encapsulates an increasing number of different technologies. This research has focused on five sub sectors:

- Wind;

- Marine and tidal;

- Carbon capture and storage;

- Nuclear; and

- Microgeneration.[1]

[1] Microgeneration is the generation of low and zero carbon heat and electricity on-site (at the point of demand). The key microgeneration sub-sectors considered in this report are solar thermal, solar photovoltaic, small scale wind, ground source heat pumps (GSHP), air source heat pumps (ASHP), biomass, combined heat and power (CHP), micro hydro and fuel cells.

The research has taken into consideration, where possible, the value chain or supply chain of activities that are relevant to each area. This typically involves research and development; manufacturing; installation and construction; and operation and maintenance. Where activities have implications for indirect employment further down the chain – for example component manufacture for wind turbines – we have, given the scope of this research, drawn out qualitative implications rather than given quantitative estimates.

The research has also taken into consideration relevant international trends and opportunities, and the implications for different regions within the UK, where appropriate.

Objectives of this study

The objectives of this study into low carbon energy generation can be summarised as follows:

- develop an overview of the economic, social and technical drivers of change for the chosen sectors and a discussion of why the sector is so important to the economy;
- develop an in-depth analysis of global and national trends in skills and employment within a selected sector; including skills insight and foresight and labour market impact. This needs to give consideration to the priority skills within the sector; and
- consider future challenges and trends for the sector, outline possible alternative sector scenarios and implications and consider how they impact on the labour market and skills.

Our approach

Our study is based on in-depth research, analysis and scenario development to help UK Commission understand the future skills needs of the low carbon energy generation sector. It provides both a qualitative and quantitative view of these requirements, and how they may evolve in the long-term. In conducting our analysis, we have drawn on the existing literature and national data on skills in the energy sector and consulted widely with the relevant Sector Skills Councils (SSCs), trade associations, employers and PwC's renewables and energy teams.

Key findings on current employment and skills

The low carbon sector accounts for less than a fifth of the UK's energy generation. Most of this is derived from nuclear power generation with renewables representing only 6 per cent of the overall total. In contrast, and despite the many natural advantages enjoyed by the UK (particularly in relation to wind and marine), almost a third of European countries surveyed by Eurostat generated more than 20 per cent of their energy from renewables.

At present, on-shore wind is the most established renewable technology in the UK. Large power companies have, however, diversified their energy portfolio, and now also invest in marine and biomass.[2] The overall value of the low carbon energy generation market in the UK (excluding nuclear) has been estimated as £31.5bn by Innovas (2009)[3] of a global total of £3 trillion, though these figures include indirect sales.

Energy from renewable sources is now high on the Government's agenda as it strives to cut CO2 emissions in line with its 2020 targets. This has resulted in the publication of the Government's UK Renewable Energy Strategy[4] in 2009 which has the ambition of generating 30 per cent of electricity from low carbon sources by 2020.

The low carbon energy generation sector is a relatively small sector in terms of direct employment. We estimate that approximately 30,000 are directly employed by the sector, of which 24,000 work in nuclear energy. The remaining 6,000 work in renewables sectors, primarily wind.[5]

In general, the energy workforce is highly skilled, with almost 40 per cent of staff educated to NQF Level 4 or 5, compared to the UK average of around a third. However, the level of qualification varies considerably across occupations and a substantial majority of energy employers report skills shortages in relation to technical, practical or job-specific skills.

Our analysis of the low carbon value chain suggests that while the UK is relatively strong in research and development and has some capability for installation and operation and maintenance, there is a relative weakness in manufacturing. Manufacturing capability was also a major concern among the industry stakeholders that we spoke to as part of this research.

Our research has confirmed that at present, there are persistent skills shortages across the sector. There are shortages in most engineering disciplines, both for highly qualified engineers and experienced technicians. There is also unmet demand for project managers with qualifications in engineering and more specialised areas such as geology, marine engineering and aeronautical engineering (Table 1). There are also more generic skills needs in the sector including project management, leadership and management skills and business development/commercialisation skills.

Concerns around the number of school-age students opting for STEM subjects at GCSE and A-level, coupled with a reported shortage of teachers in STEM subjects in the UK (OECD, 2005), are likely to exacerbate the supply of STEM students unless steps are taken to make not only these subjects, but also related careers more attractive.

[2] Biomass systems use biological material (including wood pellets and energy crops) to generate heat and electricity through combustion. Biomass can either be used in an individual dwelling or as part of a community (district) heating scheme.
[3] Innovas (2009) Low Carbon and Environmental Goods and Services: an industry analysis. Available at www.berr.gov.uk/files/file50253.pdf
[4] www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/res/res.aspx
[5] These figures include employment in the construction and installation of low carbon energy generation infrastructure.

Evidence from a number of sources suggests that the profile of the low carbon energy workforce is not markedly different from the wider energy sector workforce in terms of age and gender – perhaps unsurprising in nuclear, but arguably more surprising with the renewable technologies. Several stakeholders suggested that the industry suffers to some extent from an image problem. This view was contradicted by others, however, who believe that the sector already has an attractive reputation amongst graduates. On balance, we have no doubt that efforts should be made to present the sector as more attractive and exciting for both graduate and non-graduate careers.

There are no national statistics on employment in the low carbon energy generation sector. In part, this is due to the relative newness of the sector, but it also reflects its fragmented nature. Indeed, in the course of this study, there has been extensive debate around what exactly constitutes a 'green job'. We have, however, used a number of secondary sources to triangulate the number of jobs in our selected low-carbon sectors, with an informed estimate of a 30,000 working across the low-carbon energy generation sector.[6] While this figure has been validated with industry representatives, there is a clear need to work towards a clearer definition of the sector and its workforce, as well as future data needs, if the Government is to focus on low carbon as a priority sector.

[6] This figure includes employment in the construction and installation of low carbon energy generation infrastructure.

Table 1: Summary of current skills gaps and shortages in low carbon energy generation

Technology	Wind	Marine	CCS	Nuclear	Microgeneration
Estimated direct employment in 2009	4,000	500	0	24,000	1,000
Sector specific skills gaps and shortages	Business Development Managers with project management skills (NQF Level 5) Mechanical Engineers (NQF Level 5) Structural Engineers (NQF Level 5) Geologists (NQF Level 5) Civil engineers (NQF Level 5) Aeronautical Engineers (NQF Level 5) Project Managers (NQF Level 4) Electrical Engineers to connection wind farms to the Grid (NQF Level 4) Engineering technicians (NQF Level 3/ 4) Turbine technicians (NQF Level 3) STEM specialists generally (NQF Levels 4 and 5)	Civil engineers (NQF Level 5) Mechanical engineers (NQF Level 5) Marine engineers (NQF Level 5) Electrical engineers (NQF Level 4)	Process engineers (NQF Level 4) Power engineers (NQF Level 4) Design engineers (NQF Level 4) Knowledge of off-shore storage/site characterisation/ geology	Technical staff (NQF Levels 2 and 3) Design engineers Planners and estimators Geotechnical engineers Project managers High integrity welders Manufacturing engineers Non-destructive engineers Commissioning engineers Nuclear safety case experts A gap of highly skilled and experienced personnel is predicted to emerge driven mainly by retirement attrition	Qualified trades trained in microgeneration technologies (NQF Level 3)
Generic skills gaps and shortages in the UK which will impact the sector	Mechanical engineers (NQF Level 5)	Technology transfer skills STEM skills	Technology transfer skills Service sector consultants (e.g. legal and financial advice and climate change economics)	Management and leadership skills	Management and leadership skills Commercialisation skills

Sources: PwC analysis of stakeholder interviews and a desk based review of secondary data sources, including: AEA (2008) Future Value of Coal Carbon Abatement Technologies to UK Industry; Bain & Co. (2008) Employment opportunities and challenges in the context of rapid industry growth; BWEA (2009) Small Wind Systems UK Market Report; Carbon Capture and Storage Association (2009) Carbon Capture and Storage – building a low carbon economy; Cogent (2008) Energy Skills: Opportunity and Challenge. A Response to the Energy White Paper; Cogent (2008) Nuclear Industry Factsheet; Cogent (2009) Power People: The Civil Nuclear Industry 2009-2025; Cogent website (Available at: http://www.cogent-careers.com/roles/search and http://www.cogent-ssc.com/industry/nuclear/industry_profile.php, last accessed 21st October 2009); EU Skills (2007) Occupational and Functional Map Renewable Energy Sector; Greenpeace (2006) Solar Generation: electricity for over 1 billion people and 2 million jobs by 2020; IBM (2006) An Evaluation of the capability and capacity of the UK and global supply chains to support a new nuclear build programme in the UK; Innovas (2009) Low Carbon and Environmental Goods and Services: an industry analysis; IPPR (2009) The future's Green: Jobs and the UK low-carbon transition; SQW (2008) Skills and employment in the wind, wave and tidal sectors; and SummitSkills (2008) Report on additional research into specific themes arising from the Sector Skills Agreement for building services engineering.
Many people have contributed to the production of this report. The authors would like to thank Dr. Richard Garrett, Project Manager at the UK Commission for Employment and Skills for his encouragement and support throughout the study. Vicki Belt and Mark Spilsbury also gave advice at various stages.

Future outlook for employment and skills

In our view there will be five primary drivers of growth for the low carbon – particularly renewables – energy generation sector;

- Governance;
- Technology;
- Economic factors;
- Consumer demand; and
- Environmental change.

We consider the first two of these to be the most important. Governance encompasses Government legislation, regulation and the incentives that are being used to shape the market place and encourage private sector investment and participation. The Government's legal obligation to reduce greenhouse gas emissions by 34 per cent by 2020 (compared to 1990 levels), it's Renewable Energy Strategy and the "New Industry, New Jobs" strategy plan provide the impetus for the substitution of fossil fuels as the main source of energy generation and for the overall growth of the market.

Technology, and the level of technological innovation, is also a key driver for renewables (nuclear can be considered a well-proven technology). Different renewable technologies are at different stages of development; wind is relatively proven, notwithstanding the need for larger scale wind farms further off-shore in deeper waters; but marine and tidal, and carbon capture and storage are at a much earlier stage of development. Microgeneration is somewhat mixed. The rate at which these technologies can be deployed will be a major determinant of future employment across these sectors.

However, there are barriers to growth in the sector, including:

- Access to finance;
- Planning consent;
- The current infrastructure; and
- Supply chain weaknesses.

Access to finance has been exacerbated by the credit crunch. There are also some issues with the existing system of Renewables Obligation Certificates (ROCs)[7] that mitigate against successful raising of finance. While it is hoped that the new Infrastructure Planning Commission will alleviate some of the planning approval issues, serious concerns remain. Another issue relates to the current system of grid connection in the UK, which is currently based on a 'first come, first served basis'. In some cases, it can take several years to be connected to the grid.[8]

We consider the growth of the sector to 2020 under three different possible scenarios in the following sections. From our scenarios we have concluded that while there is a general consensus that the sector and employment in the sector will grow, the barriers to growth are potentially significant. We have identified the main opportunities for growth in the UK.

- Wind and nuclear are expected to account for a significant proportion of the capacity installed or under construction in the UK in 2020, and are likely to have the most significant impact on employment and skills requirements in 2020;

- Marine and carbon capture and storage are two emerging areas in which the UK appears to have a strong position – with the potential to become a global market leader. These technologies are at a much earlier stage of development than wind. While the scope of this study is to 2020, these technologies are unlikely to reach maturity before this date. It is clear, however, that if growth in these sub-sectors is to be achieved, consideration should be given now to developing the necessary pipeline in terms of employment and skills required;

- Small scale microgeneration is an important growth area in the Renewable Energy Strategy and deployment is expected to increase.

Under our scenarios, it is also likely that there will be markedly different levels of employment in different parts of the value chain.

- Growth in the wind sector will generate significant employment in construction and installation and in operation and maintenance of wind farms, but will also drive indirect employment for example in the high-voltage engineering required to connect new installations to the National Grid;

[7] The Renewables Obligation is the main support scheme for renewable electricity projects in the UK. It places an obligation on UK suppliers of electricity to source an increasing proportion of their electricity from renewable sources. A Renewables Obligation Certificate (ROC) is a green certificate issued to an accredited generator for eligible renewable electricity generated within the United Kingdom and supplied to customers within the United Kingdom by a licensed electricity supplier. One ROC is issued for each megawatt hour (MWh) of eligible renewable output generated. The Renewables Obligation Order came into effect in April 2002, as did the Renewables Obligation Order (Scotland). The Renewables Obligation (Northern Ireland) Order came into effect in April 2005. These Orders have been and are subject to regular review. The Orders place an obligation on licensed electricity suppliers in England and Wales, Scotland and Northern Ireland to source an increasing proportion of electricity from renewable sources. In 2005-06 it was 5.5 per cent (2.5 per cent in Northern Ireland). In 2006-07 the obligation is set at 6.7 per cent (2.6 per cent in Northern Ireland).

[8] Business Green, 25th August 2009 (see: http://www.businessgreen.com/business-green/news/2248434/miliband-moves-address-wind)

- Manufacturing jobs will be created in the period to 2020, particularly if the Government is able to encourage further investment from wind turbine manufacturers;

- The building of nuclear power stations will generate significant indirect employment in the construction industry. However, depending on the rate of new build versus decommissioning, direct employment in nuclear operations and maintenance jobs may decline to 2020.

While the workforce will need to be fed from STEM graduates, there is an experienced pool of workers in the UK off-shore oil and gas industry that have transferable skills that are applicable for example in the development and installation of off-shore wind farms, in marine installations, or in the storage of CO2 in off-shore North Sea oil and gas reservoirs. Therefore to some extent the growth in employment within low carbon energy generation could help to counteract a decline in more carbon intensive energy generation. Projections for the demand and supply of STEM graduates over the next decade demonstrate a significant shortfall in the numbers of engineers and scientists required to drive growth. In this context, the low carbon sector will need to compete for STEM graduates from industry as a whole.

There is also no clear evidence that technical jobs in the sector will change markedly over the next decade, with differences emerging a matter of degree, particularly in microgeneration. This will exacerbate the existing skills gaps and shortages outlined in Table 1. There is some likelihood, however, that a range of supporting roles may emerge: for instance, sales and marketing roles focused on communicating the benefits of low carbon to consumers and the general public.

It is also not clear whether many new jobs will emerge in the manufacturing sector, at least in the short-term. The closure of the Vestas turbine production plant in April 2009 represented a step back for low carbon manufacturing in the UK, but the outlook is brighter following Clipper's decision to establish a turbine blade manufacturing plant in the UK and the company has plans for another facility assembling gearboxes and nacelles. Furthermore, Siemens is now considering establishing a UK operation to take advantage of growth in the offshore market. The marine and carbon capture and storage sectors are at a much earlier stage of development and may represent better long-term opportunities for UK manufacturing.

Current vocational qualifications and training provision will have to adapt to the needs of low carbon employers and adult workers, particularly in light of the fact that a significant proportion of the current workforce will still be in place in 2020.

It should be noted, however, that while indirect employment is beyond the scope of this study, any growth in low carbon energy generation is also likely to lead to increased demand for associated technical consulting and financial services skills both in the UK and beyond. This demand will provide opportunities for indirect employment growth and will also impact on future skills provision.

Overall, there is still a level of uncertainty in the market for low carbon energy generation and much will depend on the effectiveness of the Government's measures to support the industry and to overcome the barriers to growth. These include: strengthening the links between businesses and further and higher education; investing in re-skilling the existing workforce; making the sector a more attractive place to work; facilitating skills transfer from other sectors and strengthening the value chain, particularly in regard to manufacturing.

Three possible scenarios for the low carbon energy sector

Our three scenarios are based on analysis of the findings from desk research and interviews with industry stakeholders and, in particular, the discussion of the drivers for change and the barriers to growth. It should be noted, however, that these scenarios present possible, rather than likely, high-level scenarios, and are dependent on a range of factors, including the state of the economy and energy and carbon markets. The actual outcome may well be more nuanced, with some sub-sectors moving ahead more rapidly, others facing delays.

It is clear that governance (by which we mean both Government support and regulation) will be one of the key forces in the development of the industry to 2020. Coupled with this will be the impact of innovation in the sector (a broad term, encompassing not only technological developments, but also private sector responsiveness to the opportunities on offer and the emergence of new ways of working to exploit the UK's strengths in research and development).

Using these two key drivers, we have developed our scenarios based on a future which holds 1) Low Governance, Low Innovation; 2) High Governance, Low Innovation; and finally 3) High Government Support, High Innovation.

The following table provides a descriptive summary of the main assumptions underpinning each of our scenarios and an overview of the main employment implications. The context for the scenarios could be considered as follows;

- for Scenario 1, financial and other constraints delay the scaling up of renewables, the development of new nuclear plants and demonstration and deployment of CCS. Renewable energy targets are missed and load growth is met through expansion of fossil fuel generation;

- for Scenario 3 – the other end of the spectrum – constraints and barriers fall away as the economy strengthens and the confidence to invest in long-term projects returns, the Government continues to put in place attractive incentives for consumers to invest in microgeneration and nuclear new builds proceed on schedule with no slippage.

Table 2: Three possible future scenarios for the low carbon energy sector: a summary

Scenario	**Description**	Implications for employment
Scenario 1: Low Governance, Low Innovation	In Scenario 1, significant barriers remain to the rollout of low carbon technologies. The UK's existing energy generation technologies maintain approximately the same proportion of the overall market as in 2009, with an increase in overall capacity in order to meet growth in the demand for energy. In this scenario, slow growth in the deployment of the low carbon technologies covered in this report may lead to increased adoption of other renewables technologies, including biomass; however, this growth would be constrained by low levels of Governance. The Government's 2020 targets for reductions in CO2 emissions are not met.	The additional 6GW of energy produced under this scenario is insufficient to meet the estimated growth in demand and an increase in the level of output and thus employment in carbon rich energy generation is required to meet the increased demand. In 2009, around 50,000 jobs[9] were involved in the production and distribution of around 70GW of energy from fossil fuels. If energy output from these sources were to increase to 80GW (or 115% of total output) as outlined in the above scenario then employment might be expected to rise to around 57,000, assuming that the ratio of jobs to unit output remains constant.[10] Under this scenario, therefore, total employment in UK energy generation could be expected to increase from around 80,000 in 2009 to 89,000 in 2020. Nuclear energy remains a key employer within the low carbon energy sector, but is almost matched by employment in wind. Employment in marine and CCS remains relatively small scale (i.e. around 1% of the the UK's low carbon energy sector).

[9] i.e. 80,000 jobs in production and distribution of electricity & gas minus the 30,000 employed within low carbon energy generation (Source: ONS (2009) in UK Employment and Skills Almanac 2009 and PwC analysis)
[10] i.e. In 2009, 50,000 jobs produced 70GW of energy, 50,000/70 = 714 jobs per GW output

Scenario	**Description**	Implications for employment
Scenario 2: High Governance, Low Innovation	In this scenario, there is moderate growth in the wind sector as a whole, driven by some off-shore development. The UK does not have a strong position in the research of CCS technology and marine technologies; only two of the planned nuclear units become operational by 2020; and microgeneration installations increase as a result of the Feed in Tariff and Renewable Heat Incentive, but overall growth is moderate.	In order to meet the increased demand for energy, the level of output and therefore the level of employment in carbon rich energy generation remains constant at around 70GW and 50,000 jobs.[11] Therefore total employment in UK energy generation is expected to rise from around 80,000 in 2009 to 97,000 in 2020 under this scenario. However, it should be noted that much of this employment growth will involve the construction and installation of significant developments to the low carbon infrastructure (particularly for off-shore wind) and therefore may be relatively short-term. To put this into perspective, construction and installation jobs are likely to make up approximately a third of employment in wind and marine (i.e. around 7,500).
Scenario 3: High Government Support, High Innovation	In this scenario, the UK achieves a strong position in CCS and marine technologies and becomes the largest market globally for off-shore wind. The significant size of the UK renewables market acts as a further driver for investment in the UK. CCS and Marine technologies may not yet be deployed on a large scale, but the UK has a strong role in research, demonstration and testing and is developing the necessary value chain to benefit from rollout in the coming years. Microgeneration technologies are installed on a significant share of buildings (new and retrofit). There is zero slippage in the timescales for new build nuclear and three units are operational by 2020.	Under this scenario, the increase in the capacity is enough to cover the estimated increase in demand for energy and allow for a reduction in carbon rich energy generation. The significant increase in low carbon employment (which has approximately doubled since 2009) is therefore likely to be offset by a declining employment in carbon rich energy generation sectors. If energy output from these sources were to decline from 70GW to 53GW (or 54% of total output) then employment might be expected to decline from around 50,000 jobs[12] to around 40,000 (assuming that the ratio of jobs to unit output remains constant).[13] Under this scenario, the overall impact on employment in UK energy generation would be an increase from around 80,000 in 2009 to 111,000 in 2020, creating the potential for skills transfer. The construction and installation skills required in the off-shore oil and gas industry could, for example, be applied to off-shore wind farms and knowledge of depleted oil wells could be used in site characterisation for the storage of CO_2.
		A further point to note is that, as in Scenario 2, this Scenario will involve significant developments to the low carbon infrastructure, which will generate employment in short- to medium-term activities such as construction and installation. To put this into perspective, construction and installation jobs are likely to account for 12,000 positions in wind and marine (i.e. around 30%). Employment growth across the UK energy sector as a whole is therefore minimal and the issue is more one of re-skilling the existing workforce than creating a new low carbon workforce.

Source: PwC analysis of stakeholder interviews and desk based review of secondary data sources. For a full list of the data sources used see Annex F.

[11] i.e. 80,000 jobs in production and distribution of electricity and gas minus the 30,000 employed within low carbon energy generation (Source: ONS (2009) in UK Employment and Skills Almanac 2009 and PwC analysis)
[12] i.e. 80,000 jobs in production and distribution of electricity & gas minus the 30,000 employed within low carbon energy generation (Source: ONS (2009) in UK Employment and Skills Almanac 2009 and PwC analysis)
[13] i.e. 714 jobs per GW output

Industry insight: wind

Estimates of the level of employment in the UK wind sector vary widely. Our view is that employment is currently relatively small-scale, with only around 4,000 directly employed in the sector.[14]

Employment is weighted towards system integration and installation (32 per cent), and maintenance and operations (28 per cent) than it is towards manufacturing (18 per cent) or other activities. This represents the nature of the value chain of activities in the UK; a sector that has considerable potential for an increase in on- and off-shore turbine installation, but which no longer has a major turbine manufacturer present. With the closure of the Vestas plant in the Isle of Wight, 500 manufacturing jobs have been lost. This is likely to have had a detrimental effect on employment in downstream component suppliers to Vestas, but we have not attempted to quantify the impact of the closure given our focus on direct rather than indirect jobs in the sector as a whole.

Employment is higher in the on-shore wind sector (75 per cent of jobs) than off-shore (25 per cent of jobs). However, the UK has the highest potential, in terms of natural resources, in Europe for off-shore wind, suggesting that off-shore-related jobs could increase rapidly. As the sector grows there will be implications for jobs downstream; these will not necessarily be turbine manufacture, but are likely to be related to the infrastructure that will be essential for the sector to flourish and could include employment in marine construction (to further develop the port infrastructure) and employment in electrical engineering (for the design and construction of the high-voltage connections between wind farms and the National Grid).

Within the value chain there is a wide array of jobs, from degree and post-graduate acoustic and design engineers, construction project managers, wind turbine technicians and production engineers and operatives. This diversity of employment creates a need for courses from a short industry course in wind turbine technology to a Masters or Postgraduate Diploma in Renewable Energy. This variety of tailored skill requirements needs to be recognised in terms of training provision within the sector.

Identified skills shortages within the sector include:

- Mechanical and electrical engineers with a postgraduate qualification;
- Structural Engineers with a postgraduate qualification;
- Turbine technicians with the skills and qualifications required to operate inside the nacelle of a wind turbine;

[14] This figure includes employment in the construction and installation of wind farms.

- Geologists, civil engineers, aeronautical engineers; and
- Project managers with an engineering qualification.

There are currently over 50 specialist training courses ranging from postgraduate qualifications awarded by universities to part-time vocational courses run by private training providers. The university courses appear to be well subscribed, but there are concerns regarding the supply of technicians with Level 2 and Level 3 qualifications.

Industry insight: marine

The marine power generation sector is still currently at a relatively early stage in its development; it is a far less well proven technology than power generation from wind. Our estimate of direct employment in the marine sector is less than 500.[15]

Given the early stage of development of the sector, and the nature of the projects underway to prove technical and commercial viability, employment is currently limited to research and development activities, with a small manufacturing component. It is an industry which has the potential to create direct employment in all parts of the value chain, particularly planning and design, manufacturing, construction and installation and operations and maintenance, however, in our view, it is unlikely to create substantial employment by 2020.

Current skills needs within this sub-sector are primarily in engineering research and development. However, as the technology is deployed on a larger scale, employment and the corresponding skills needs will become more diverse, and are likely to be similar to those in the wind sub-sector.

As with the wind sector, marine and tidal resources in the UK offer great long-term potential. Furthermore, given the very early stage of development, the potential exists to develop not just commercial technology, but also a manufacturing base, with the potential for downstream component supply. Assuming commercial viability, there would be a related need for electrical engineers (for the design and construction of the high-voltage connections between marine installations and the National Grid).

Specialist training courses in marine technologies are limited at present, but more might reasonably be expected in the medium to long-term as the industry grows in scale.

Industry insight: carbon capture and storage (CCS)

Estimates of direct employment in the carbon capture and storage (CCS) sector in the UK vary. Our view is that employment is currently negligible. Given the early stage of development of the sector, employment is currently located in research and development.

[15] This figure includes employment in the construction and installation of marine energy generation infrastructure.

However, given the UK's current reliance on fossil fuel power generation, and the capacity to store a significant volume of CO2 in the depleted gas fields and oil fields in the North Sea, this is again a sector with considerable potential for long term growth. Expert interviews suggest the UK risks losing ground on competitors around the world, as countries like the US and Norway press ahead with ambitious CCS programmes.

While skills required will be specific to particular technologies, the fundamental disciplines will be very much the same as those for other power generation sectors and for the off-shore oil industry. Skill requirements will include high-level qualifications in process, power and design engineering, and knowledge and skills related to the UK's off-shore storage infrastructure.

The demand for technology transfer skills will increase as the technologies develop and greater university-industry collaboration is required to facilitate the transition from demonstration and deployment. There will, in due course, be a need for legal and financial advice, and economists.

There is the potential to transfer skills from other industries, in particular the UK oil and gas industry. Off-shore engineering skills from the UK oil and gas industry could be used to build new or modify the existing infrastructure necessary for CO2 storage sites. Also the extensive knowledge of the UK's depleted oil and gas reservoirs that currently exist within the oil and gas industry will be invaluable to the development of the sector.

Some estimates exist for the long-term employment potential of CCS assuming the technology is actively deployed in fossil fuel power stations. Estimates indicate that UK employment in CCS could reach 30,000[16] and that these jobs will be in design and manufacture. In the period to 2020 jobs created will be related to demonstration projects. Notwithstanding the manufacturing and construction related to demonstration projects we have considered this employment to be in the Research & Development end of the supply chain.

On balance, given the early stage of development of the sector, the potential for growth, and the depth of expertise in related UK industries, our view is that the UK could have a strong position in the CCS market, with the ability to export some services and expertise. However, the sector is unlikely to create substantial levels of employment between now and 2020.

Industry insight: nuclear

In the absence of national statistics on the nuclear workforce, Cogent, as the SSC for the industry, has undertaken a significant programme of research in this area. We have drawn on this research as the most reliable evidence base at present.

[16] AEA (2008) Future Value of Coal Carbon Abatement Technologies to UK Industry

Direct employment in the nuclear industry is approximately 24,000.[17] Indirect employment in the supply chain and the construction of new builds accounts for a further 20,000 or so jobs. More than half of this employment is in the North West of England. The expected lifespan of the UK's current civil nuclear fleet means that a number of units are due to go off-line over the next decade. This will have a knock on effect of reducing both direct and indirect employment. The scale of this reduction in the overall workforce will be heavily dependant on the volume and timing of future new builds, which could potentially require a significant volume of construction work over a relatively short timeframe.

In general the workforce is more highly skilled (NQF Level 3 or 4) and a greater proportion of the workforce is engaged in professional and technical roles than the UK average. However, the workforce profile is also ageing faster than the UK workforce as a whole. Cogent estimates that up to 70 per cent of the current nuclear workforce will have retired by 2025. Even accounting for the overall reduction in demand, this retirement attrition has the potential to create a significant skills gap, as the most experienced personnel – often managers or senior officials – begin to retire. Therefore effective transition planning must take place to ensure that younger staff acquire the skills and expertise necessary to fill this gap. There is considerable work underway by bodies like the National Skills Academy for Nuclear and the Office for Nuclear Development to ensure that the skills and supply chain needs of the sector are met.

Industry insight: microgeneration

In the absence of a comprehensive data source covering direct employment in microgeneration technologies we have estimated total employment in 2009 to be 1,000.[18] This is based on the number of design, manufacturing, installation and maintenance jobs linked to these technologies within the UK. Our desk-based research and stakeholder interviews suggest that system design, installation and maintenance activities are currently undertaken by employees within the building services engineering sector (i.e. electrical trades and installation, plumbing, heating and ventilation and air conditioning and refrigeration).

Few additional jobs appear to have been created by design, installation and maintenance of microgeneration technologies to date. Evidence suggests this is because, on average, installers have generally only undertaken a handful of installations each. In the case of discretionary technologies, which are installed in addition to traditional technologies (e.g. gas boilers), additional jobs may be created in the future because these technologies are not displacing existing systems and also because many forecasts suggest households may have multiple microgeneration systems installed.

Essential microgeneration technologies, on the other hand, are installed as an alternative to traditional technologies and are unlikely to create significant new employment opportunities in the UK. However, the demand for the design, installation and maintenance of microgeneration systems is beginning to change the types of activities undertaken by employees within the building services engineering sector.

[17] This figure includes some employment in the construction of nuclear energy generation infrastructure.
[18] This figure includes employment in the construction and installation of microgeneration equipment.

Research conducted by SummitSkills in 2008[19], found that the involvement of UK building services engineering companies in microgeneration technologies varied greatly depending on the type of technology (i.e. from 2 per cent involved in micro hydro and fuel cells to 29 per cent involved in CHP). This research also identified significant regional variation in terms of the prevalent type of renewables technology, but with no apparent rationale for this selection.

Around one in ten UK building services engineering companies has employed migrant labour within the last three years. This has the potential to result in staff shortages (and therefore create skills gaps and shortages) for the sector going forward as many migrant workers may choose to return to their country of origin or because of the recession may move on to other countries which are able to offer more attractive employment packages.[20]

However, the design, installation and maintenance of microgeneration systems does not require very different skills than those which already exist within building services engineering sector. It will require some additional underpinning knowledge, in terms of system design, integration with other technologies and for some technologies – health and safety. Qualified trades persons could acquire this knowledge relatively easily via a short training course.

Training provision for microgeneration technologies is low and has traditionally been supplied by manufacturers. There are currently no identified skills gaps in this area due to the relatively low levels of demand for microgeneration installations to date. However, weaknesses in management and leadership, business acumen and entrepreneurship skills have been identified within the building services engineering sector in general, which could create productivity issues for microgeneration in the future.

To some extent demand for technical training needs to be stimulated by the sector, however, if providers are not proactive in developing and increasing the supply of training courses they may be unable to meet a sudden increase in demand due to the increased uptake in microgeneration technologies. This may create a skills gap, which will have negative implications for the quality and scale of the UK's microgeneration activities.

[19] SummitSkills (2008) Report on additional research into specific themes arising from the Sector Skills Agreement for building services engineering

[20] SummitSkills (2008) Report on additional research into specific themes arising from the Sector Skills Agreement for building services engineering

1 Introduction

PricewaterhouseCoopers LLP(PwC) was commissioned by the UK Commission for Employment and Skills (the UK Commission) in September 2009 to provide an assessment of the skills needs in the low carbon energy generation sector to support its work on the National Strategic Skills Audit for England, 2010. The impetus for the Audit came from the policy document, New Industry, New Jobs, published by the then Department for Business, Enterprise and Regulatory Reform in April 2009. In it, the authors emphasise the importance of a more strategic approach to skills in the changing economy:

> *"… The Government also has to do more to help equip high potential British firms. We need to take a range of actions. We must improve the skills of our people and adapt them to the specialist demands of a modern economy; strengthen our capabilities in research and development; innovate further in science and technology, and industrialise this innovation in commercially successful ways. These actions are the bridges to our economic future."*

New Industries, New Jobs identified low carbon as one of six priority sectors for development. This document was followed in July 2009 by the Low Carbon Transition Strategy which noted that the global market for low carbon and environmental goods and services (LCEGS) was already worth £3 trillion in 2007/08 and that the UK is in a strong position to develop its base in this sector (from an estimated £31.5bn) [21].

Given the potential importance of this sector to the economy, this report provides a timely response to the current debate into the UK's strategic skills needs.

Our study is part of a wider exercise designed to contribute towards the UK Commission's overall response to strategic skills, the National Strategic Skills Audit. This Audit, which is supporting current Government-led developments around industrial and skills activism, is comprised of a number of strands, including:

- **A national assessment:** to provide a strategic national overview and assessment of immediate and emerging priority skills needs in both existing and emerging industries. This will also include a regional assessment, providing a consistent and comparable skills assessment across the English regions;

- **Priority sectors assessments**: to provide an assessment of the skills needs of key, selected priority sectors; and

- **Horizon scanning:** to provide an assessment of what the future may hold by scanning the horizon, exploring important emerging issues and developments and bridging policy-making in the short and long term.

[21] Innovas (2009) Low Carbon and Environmental Goods and Services: an industry analysis. Available at www.berr.gov.uk/files/file50253.pdf Please note that this figure includes indirect sales.

The 25 employer-led Sector Skills Councils are, at the same time, reporting to the UK Commission on their individual sector skills priorities, and, working in 'clusters' examining the skills needs in six key areas (including low carbon) to enable the UK Commission to triangulate the overall skills needs of the UK economy to 2020 and to help inform the planning of higher and further education provision in the years to come.

The low carbon sector evidently encompasses a wide range of sectors and services, from energy generation, to logistics, and indeed, the precise definition of the sector has been the subject of some discussion during the course of this study. Section 1.2 below presents the rationale for selecting low carbon energy generation for analysis and defines the scope of the research in this sector.

1.1 Scope of research

Low carbon energy generation encapsulates an increasing number of different technologies including wind, biomass[22], geothermal and solar power. To focus the scope of the research, five important sectors have been identified through interviews with market experts.

The five sectors identified are wind, nuclear, marine, carbon capture and storage, and microgeneration.[23] Wind and nuclear are expected to account for a significant proportion of the capacity installed or under construction in the UK in 2020, and marine and carbon capture are two emerging areas in which the UK appears to have considerable potential for growth. Microgeneration has been selected because small scale generation, particularly for heat energy, is an important growth area in the Government's renewable strategy and deployment is expected to increase once the feed in tariff and renewable heat incentive are in place in 2010 and 2011 respectively.

Previous studies (including various Carbon Trust reports and a report by the EEF) as well as our own market interviews suggest these sectors will have the most significant impact on employment and skills requirements in 2020 and beyond. It should be noted that other sectors including, for example, large scale biomass have the potential to generate employment in the same time horizon..

1.2 Objectives of this study

The objectives of this study into low carbon energy generation can be summarised as follows:

- Develop an overview of the economic, social and technical drivers of change for the chosen sectors and a discussion of why the sector is so important to the economy;

[22] Biomass systems use biological material (including wood pellets and energy crops) to generate heat and electricity. Solar energy is captured and stored during the photosynthesis process, which is then converted to heat and/or electricity during the combustion process. Biomass can either be used in an individual dwelling or as part of a community (district) heating scheme.

[23] Microgeneration is the generation of low and zero carbon heat and electricity on-site (at the point of demand). The key microgeneration sub-sectors considered in this report are solar thermal, solar photovoltaic, small scale wind, Ground Source Heat Pumps (GSHP), Air Source Heat Pumps (ASHP), biomass, Combined Heat and Power (CHP), micro hydro and fuel cells.

- Develop an in-depth analysis of global and national trends in skills and employment within a selected sector; including skills insight and foresight and labour market impact. This needs to give consideration to the priority skills within the sector; and

- Consider future challenges and trends for the sector, outline possible alternative sector scenarios and implications and consider how they impact on the labour market and skills.

1.3 Methodology

Our study is based on in-depth research, analysis and scenario development to help the UK Commission understand the future skills needs of the financial services and low carbon energy generation sectors. It provides both a qualitative and quantitative view of these requirements, and how they may evolve in the long-term.

In conducting our analysis, we have drawn on the existing literature and national data on skills in the energy sector and consulted widely with the relevant Sector Skills Councils (SSCs), a number of trade associations and employers and internal PwC subject matter specialists.

The remainder of this report is structured as follows:

- Industry insight: an overview;
- Industry insight: wind;
- Industry insight: marine;
- Industry insight: carbon capture & storage;
- Industry insight: nuclear;
- Industry insight: microgeneration;
- Industry foresight;
- Three potential futures for the low carbon energy sector; and
- Conclusions.

It also contains five Annexes:

- Annex A: Employment and skills in the energy sector as a whole;
- Annex B: The National Qualifications Framework;
- Annex C: EWEA European on-shore wind atlas;
- Annex D: Comparison of PwC and Ofgem scenarios; and
- Annex E: Glossary;
- Annex F: Bibliography.

2 Industry insight: an overview

Chapter summary

The low carbon sector accounts for less than a fifth of the UK's energy generation. Most of this is derived from nuclear power generation with renewables representing only 6 per cent of the overall total. In contrast, and despite the many natural advantages enjoyed by the UK (particularly in relation to wind and marine), almost a third of European countries surveyed by Eurostat generated more than 20 per cent of their energy from renewables.

At present, on-shore wind is the most established renewable technology in the UK. Large power companies have, however, diversified their energy portfolio, and now invest in not only wind, but also marine and biomass. The overall value of the renewables generation market has been estimated as £31.5bn, though this figure includes indirect sales and excludes nuclear (non-renewable), which we include in our low carbon energy definition.

Energy from renewable sources is now high on the Government's agenda as it strives to cut CO2 emissions in line with its 2020 targets. This resulted in the publication of three Government strategies in 2009:

- **Low Carbon Transition Plan** (2009): overall UK strategy for low carbon across all sectors (not just energy);
- **UK Renewable Energy Strategy** (2009): strategy to achieve the energy element of the transition plan (30 per cent of electricity from renewables by 2020 etc);
- **The UK Low Carbon Industrial Strategy** (2009): strategy to develop the UK supply chain in low carbon across all sectors (not just energy).

Our analysis of the high-level low carbon value chain demonstrates that while the UK is relatively strong in research and development, installation and operation and maintenance (notably in wind), there is a relative weakness in manufacturing. Manufacturing capability was also a major concern amongst the industry stakeholders that we spoke to as part of this research.

There is a lack of official statistics on employment and skills in the low carbon energy generation sector as the sector is captured by the wider energy and utilities sector. In part, the lack of official data on the low carbon sector reflects its early stage of development, but also its fragmented nature. We have therefore used a number of secondary sources to estimate of the number of jobs in the renewables sector at 30,000.[24] While this figure has been validated with industry representatives, there is a clear need to work towards a clearer definition of the sector and future data needs if the Government is to focus on low carbon as a priority sector.

[24] This figure includes employment in the construction and installation of low carbon energy generation infrastructure.

Evidence from a number of sources suggests that the profile of the low carbon energy workforce is not markedly different from the wider energy sector workforce demographics in terms of age and gender. Several stakeholders suggested that the industry suffers to some extent from an image problem. This view was contradicted by others, however, who believe that the sector already has an attractive reputation amongst graduates. On balance we have no doubt that efforts should be made to present the sector as more attractive and exciting for graduates and non-graduate careers.

As with the industry as a whole, low carbon energy generation is heavily dependent on STEM skills – and shortages in this area across industry are already well-documented. Other specific skills needs identified include: project management, generic leadership and management skills, and business development.

2.1 Introduction

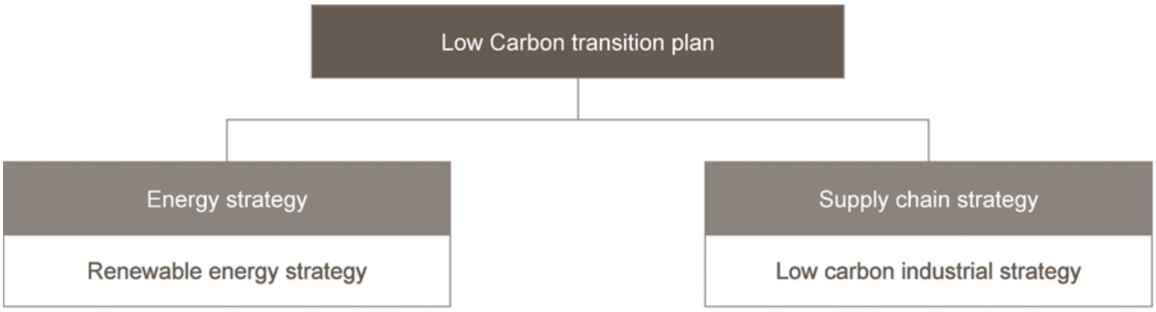
This chapter of the report provides an overview of the low carbon sector as a whole. It summarises the Government's strategy for low carbon, the current state of the low carbon market, the key stages in the low carbon value chain, and current employment and skills in the sector. It is structured as follows:

- Overview of Government strategy on low carbon;
- The current state of the UK's low carbon energy market;
- The UK low carbon value chain;
- Current employment in the low carbon energy generation sector;
- Current skills provision and needs in low carbon energy generation; and
- Conclusions.

2.2 Overview of Government strategy on low carbon

The Department of Energy and Climate Change (DECC) released three plans for the low carbon sector in July 2009. These are: the Low Carbon Transition Plan; the Renewable Energy Strategy; and the Low Carbon Industrial Strategy. Figure 1 below illustrates the hierarchy of these strategies.

Figure 1: Hierarchy of Government strategy publications on low carbon/renweables energy in 2009



Source: PwC analysis of the UK Government reports relating to the strategy on low carbon energy

The Low Carbon Transition Plan is the principal strategy which "sets out the UK's transition plan for becoming a low carbon country: cutting emissions, maintaining secure energy supplies, maximising economic opportunities, and protecting the most vulnerable". The intention is to cut emissions by 18 per cent to 2020. The plan encompasses power and heavy industry, transport, homes and communities, workplace, jobs and farming, and the land and waste sectors.

The Renewable Energy Strategy is a targeted strategy to achieve the renewables aspect of the Transition Plan. It outlines specific objectives to generate 30 per cent of electricity from renewables, 12 per cent of heat from renewables and 10 per cent of transport energy. The Strategy describes how these goals will be achieved through financial support (Renewables Obligations, Feed in Tariffs, and Renewable Heat Incentives), improvements to the transmission infrastructure, smart grids and the potential for the Severn Barrage. It also considers the roles of the different bodies such as Regional Development Agencies and local authorities.

The Low Carbon Industrial Strategy is essentially a plan to develop the low carbon strategy supply chain. Its objective is "to ensure that British businesses and workers are equipped to maximise the economic opportunities and minimise the costs". The Strategy includes the broader scope of low carbon industries including energy, construction, aerospace, chemicals, business and finance. This Strategy considers issues such as: the creation of low carbon economic areas; support for innovation; advice for businesses; and funding gaps.

2.3 The current state of UK's low carbon energy market

The energy generation sector is the largest source of carbon dioxide emissions in the UK, accounting for 40 per cent of the total. Gas and coal are currently the primary energy sources, accounting for approximately 75 per cent of electricity generation, with nuclear making up another 13 per cent, and renewables responsible for just 6 per cent.[25] The current breakdown of energy generation by sub-sector, alongside Government projections for the industry 2020, are illustrated in Figure 2.

On-shore wind is currently the most heavily deployed renewable technology in the UK, with circa 4GW of installed capacity powering 2.3 million homes, followed by biomass and hydroelectric power.[26] Localised energy generation has grown slowly in the UK and there were approximately 100,000 installations by the end of 2007, delivering around 16MW of grid connected electricity.[27] Solar thermal is the dominant microgeneration technology installed to date, driven by the relatively low up-front cost.

Utilities companies in the UK have embraced renewable technologies following the creation of Renewables Obligations, and the majority of companies now have a diverse energy portfolio. E.ON for example has adopted hydroelectric, off-shore and on-shore wind and biomass, RWE npower primarily uses wind, but is developing hydro, marine and biomass capabilities, while EDF and Scottish Power use mainly wind turbines, but have invested in marine research and development (R&D).

As indicated in the section above, low carbon energy generation is now high on the Government's agenda. The UK has a legally binding obligation to reduce greenhouse gas emissions by 60 per cent below 1990 levels by 2050, and by 34 per cent by 2020.

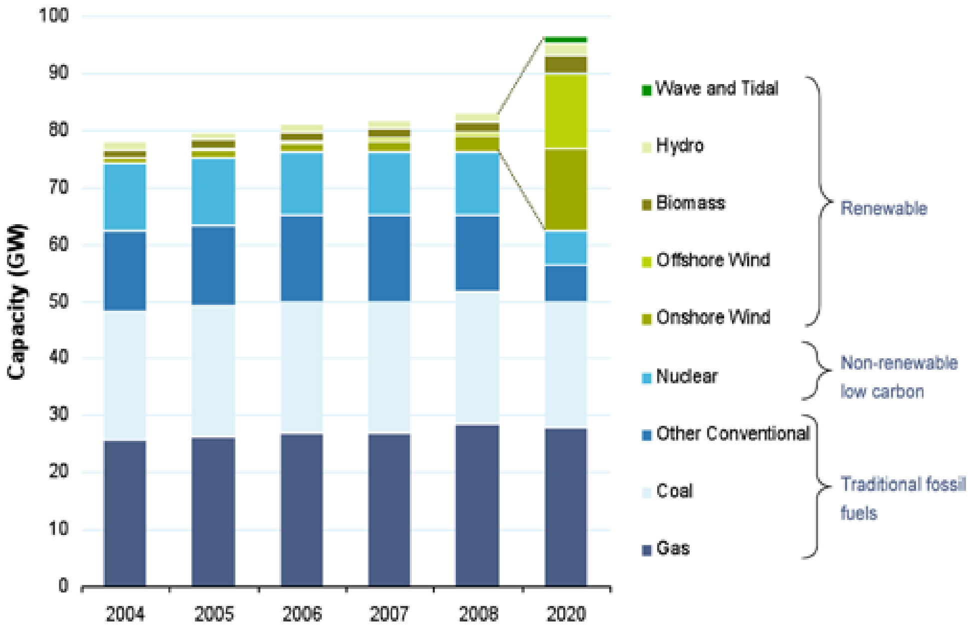
Also this year, in October 2009, Ed Miliband, Secretary of State for Energy and Climate Change, announced new legislation to speed up the planning process. This was prompted by the need for one third of generating capacity to be approved and built over the next 15 years to meet these targets.

[25] DECC, (2009) Energy Trends

[26] Hydroelectric power is generated through dams from running or flowing water. This is distinct from marine energy generation.

[27] Element Energy (2008) The Growth Potential for Microgeneration in England, Wales and Scotland

Figure 2: A scenario for UK energy generation to 2020



Source: UK Renewable Energy Strategy (2009) – Renewables ; SKB (2008) – Non-Renewable Carbon & Traditional

The UK Government's vision for renewables in 2020, on which Figure 2 is based, is elaborated in the 2009 UK Renewable Energy Strategy. The forecast for non-renewable and traditional sources is based on the middle scenario in the SKM report Growth Scenarios for the UK Renewables Generation and Implications for Future Developments and Operation of Electricity Networks because the various renewable strategy documents do not include forecasts for non low carbon energy generation sub-sectors.

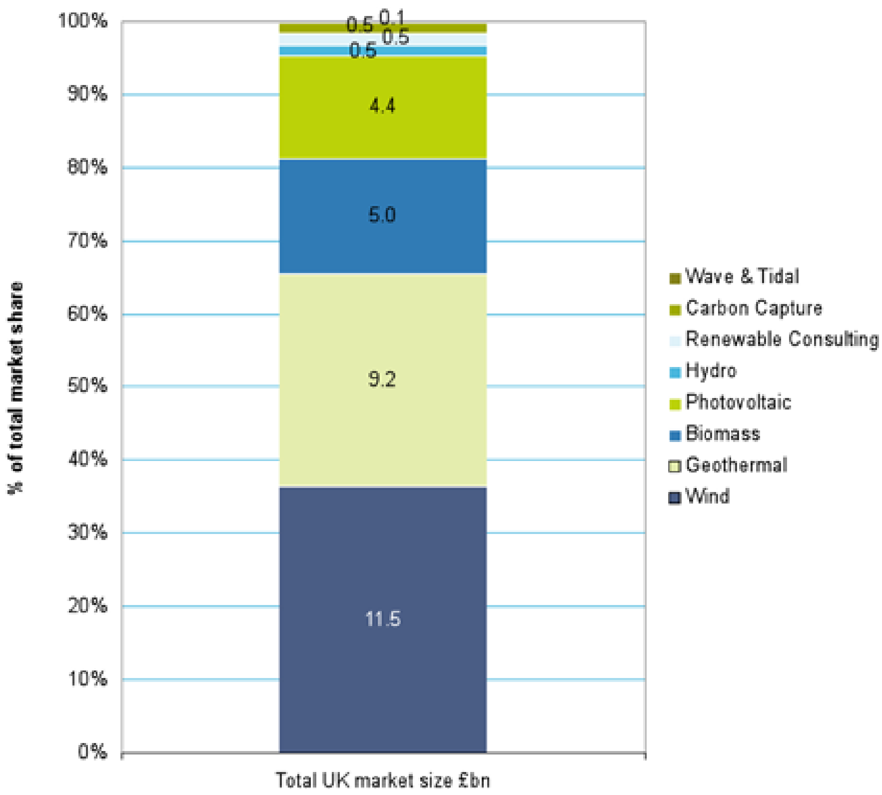
2.3.1 Value of the low carbon energy generation sector to the UK economy

The then Department for Business, Enterprise and Regulatory Reform (now the Department for Business Innovation and Skills) commissioned Innovas in 2009 to undertake a study of the low carbon and environmental goods and services (LCEGS) market. This study covers the sales activity of those UK companies which generate at least 20 per cent of their revenue from the LCEGS market. It suggests that the total global LCEGS market is estimated at £3 trillion annually, of which the UK is valued £106bn, and the UK low carbon energy generation market is estimated at £31.5bn.[28]

[28] In the Innovas report, LCEGS encompasses Environmental Services (air pollution, waste management etc) valued at £22.3 bn and the Emerging Low Carbon Sector (alternative fuels for vehicles, building technologies etc valued at £53.3 bn) as well as the Renewables sector (£31.1 bn). The Innovas report presents the value for Carbon Capture and Storage (£0.46bn) in the Emerging Low Carbon sector. For the purposes of this report, we have added the CCS figure to the Renewables sector value.

While, as we discuss in greater detail in subsequent sections, the figures in the Innovas report appear somewhat high and seem to include a greater proportion of the supply chain than other sources, this is the only comprehensive study of the low carbon sector undertaken to date. This data has also been adopted in a number of other Government renewables strategy documents, including the 2009 UK Low Carbon Industrial Strategy. The Innovas report also excludes the nuclear sector (non-renewable) which have been included in our definition of low carbon. Figure 3 presents the estimated size of the UK market by eight forms of low carbon technology examined in the Innovas report (which includes renewable consulting).

Figure 3: Estimated UK market size by Irenewable technology (2007-8)



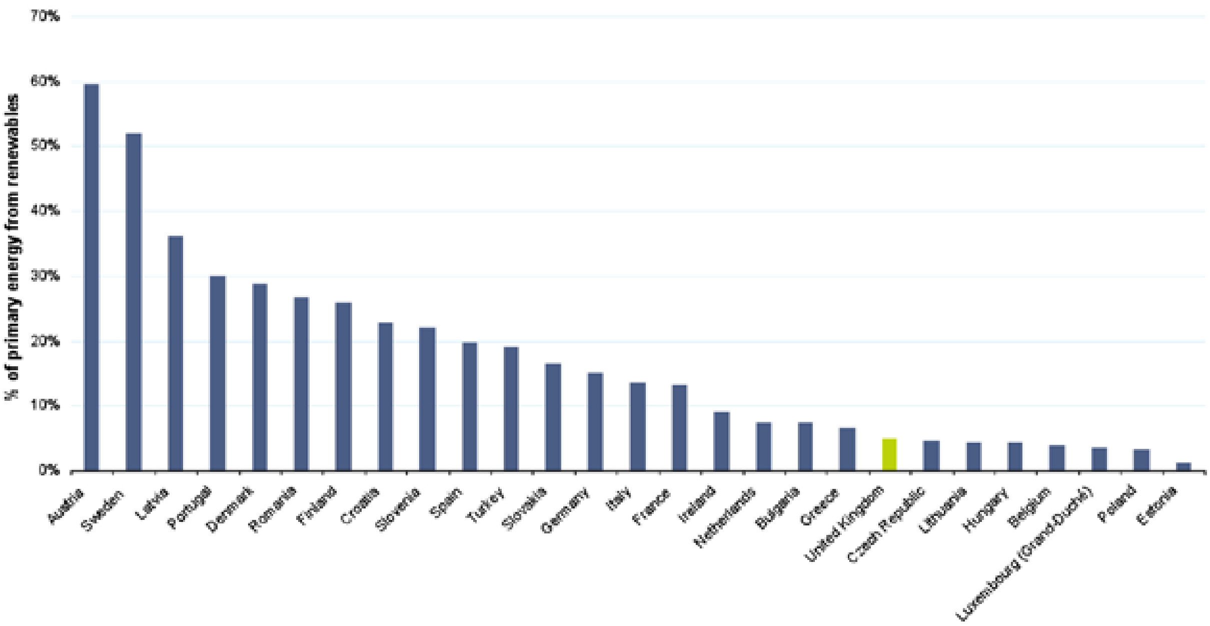
Source: Innovas (2009)

Some sub-sectors of low carbon energy generation tend to be concentrated in specific geographical locations around the UK. While microgeneration is evidently distributed across the UK, and nuclear sites are relatively dispersed (outside urban areas), wind and marine energy generation is predominately located in Scotland (with marine also clustered in the South West). Further details on regional variations on the distribution of specific low carbon technologies are provided in the chapters which follow this overview.

2.3.2 UK renewables generation compared to generation in Europe

Despite the importance of renewable energy in Government strategy, renewable energy currently represents a minimal share of primary energy generation, particularly when compared to other European countries. Figure 4 represents the proportion of primary energy generated from renewables in 27 European states. It is clear that the UK lags considerably behind most of Europe at 20th in this survey, with Austria and Sweden generating more than 50 per cent of their total energy from renewables.

Figure 4: Renewables share of primary energy generation (2007)



Source: Eurostat (2007)

2.3.3 The UK's natural advantages in renewable energy generation

Despite this relatively low starting position in relation to many other European countries, the UK is well-positioned, in terms of its natural assets, to exploit renewables to a much higher degree. This is particularly the case in relation to on- and off-shore wind.

The UK has some of the strongest on-shore wind speeds in Europe (particularly around Scotland), and the UK on-shore resource has been estimated at 40TWh per year. The potential for off-shore wind energy is even greater. Estimates of the UK's off-shore resource vary significantly from 67TWh to 1,000TWh.[29] The expectation is that the UK will have the largest off-shore wind farm market globally by 2020. In addition, the wind farm planned for the Thames Gateway will be the world's largest farm. The UK also has a strong marine (wave and tidal) resource, which, according to the Renewable Energy Association, represents 50 per cent of Europe's wave energy resource and 35 per cent of its tidal resource.[30]

[29] Ofgem (2007) Energy Markets Outlook: Chapter 9: Renewable and Low Carbon Energy

[20] REA website, 23rd September 2009 (see: http://www.r-e-a.net/info/rea-news/0909REA_NEJointStatement/)

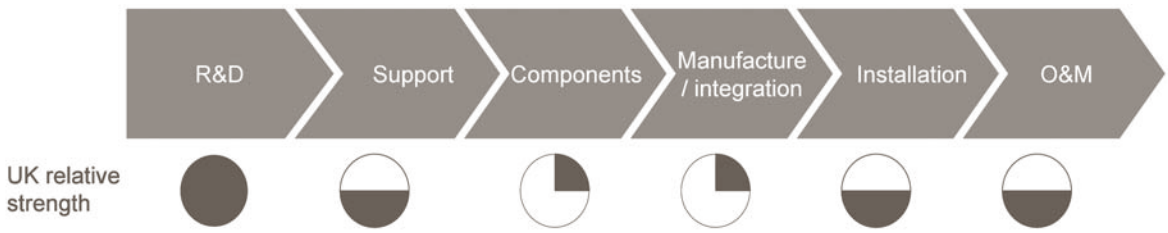
In the Carbon Capture and Storage sector, research by Dr Haszeldine, Professor of Sedimentary Geology at Edinburgh University, which was recently cited in The Times (9/09/2009)[31], suggests that the UK controls sandstone rock formations beneath the sea have the potential to store 150bn tonnes of CO2. This is the equivalent of hundreds of years of CO2 output from UK fossil fuel power stations. With the exception of Norway, the UK has more CO2 storage space than the rest of Northern Europe combined. This creates the potential for the UK to sell licences to other European countries to store their CO2 emissions, which could, in turn, generate significant revenue and create new jobs. The UK will obviously be in a stronger position in this regard if it has a market leading position in CCS when the technology reaches the deployment stage.

2.3.4 The UK low carbon value chain

UK companies were well placed in the Guardians top 100 list for European Clean Technology companies and 52 of the top 100 companies were UK based (across all Clean Technology sectors). Three UK companies are also placed in the top 10; Marine Current Turbines, Pelamis Wave Power and Scotrenewables, all of which are in the marine sector. This list is a collaboration between the Guardian and the Cleantech Group which highlights the most promising private clean technology companies in Europe based on the views of hundreds of leading experts and venture capital companies.

Figure 5 illustrates the current value chain in the low carbon energy sector. It is a high-level summary, based on our research and analysis of the low carbon sub-sectors which are the subject of this study. In this chain, the UK is strong in its low carbon R&D capability but weak in the manufacturing and integration phase. Indeed, in the interviews with leading industry figures that we have conducted in the course of this research, the lack of manufacturing capability in this sector has emerged as a very significant concern.

Figure 5: UK Strength in the low carbon value chain



Source: PwC analysis of stakeholder interviews

[31] The Times website, 9th September 2009 (See: http://www.timesonline.co.uk/tol/news/science/earth-environment/article6826737.ece)

The paragraphs below describe in more detail each of the stages in the UK low carbon value chain. Value chains for the specific sub-sectors are explored in the chapters which follow this overview. It should be noted, however, that this value chain provides an overview of the sector as a whole. The respective value chains for each sub-sector will vary according to the nature of the sub-sector and its stage of development.

2.3.5 Research and development

The UK has a strong history of innovation and is a world leader in scientific research[32] and has taken a leading position in the research and development of new low carbon generation technologies including marine, CCS, and to a lesser extent, off-shore wind. The Low Carbon Innovation Centre and Carbon Connections, for example, two low carbon research bodies, have been established at the University of East Anglia. The latter was established in 2006 to nurture innovation from the Higher Education Sector and encourage partnerships with industry.[33] The UK is also home to marine energy research, with support including investment from the Carbon Trust such as the Marine Development Proving Fund and the Marine Renewables Proving Fund. Almost half the world's marine energy technology developers are based in the UK and there are two demonstration sites in the UK in Orkney and Cornwall.[34]

In the off-shore wind sector, the Technology Strategy Board, a group focused on stimulating technology-enabled innovation in the UK, has several ongoing wind research projects, including research into cost effective off-shore foundations, rapid production of off-shore rotor blades, wireless monitoring of off-shore wind towers and blades, and the deepwater wind farm demonstrator project. There are also several collaborative research projects underway in the UK, including Project Helm Wind which is carrying out feasibility study for an off-shore specific wind farm, and Project Deepwater Turbine, which is studying the potential for a five MW floating off-shore wind turbine. In the CCS sector, the Scottish Centre for Carbon Storage is supporting research into the technology and the Government's CCS competition is driving private investment into the market. Difficulties in translating low carbon research into commercial success are discussed later in this chapter.

2.3.6 Support services

Support services includes a number of capabilities including project development, financing, project management, and specialist consultancy, some of which have been identified as generic skills gaps (see Table 1). The UK has several large project development companies, including Renewable Energy Systems, a McAlpine subsidiary.[35] The UK is also home to some of the leading low carbon consultancies, including Garrad Hassan, who specialise in wind, marine and solar technical services. In regard to such services, therefore, there is some current capability in the support services value chain.

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[32] HMG (2008) Building a low carbon economy

[33] Innovation UK website, 4th October 2009 (see:http://www.innovationuk.org/news/innovation-uk-vol5-2/0176-innovation-in-the-uk-is-alive-and-well.html)

[34] IPPR (2009) The Future's Green: Jobs and the UK low-carbon transition

[35] REA website (see: http://www.r-e-a.net/power/wind-power/UK_market) Last accessed 1st December 2009

2.3.7 Components

The UK has strengths in the component value chain in other sectors (aviation, automotive, marine), but has more limited involvement in renewables. In the wind sector, the potential wind component suppliers are reluctant to diversify into the market without a sufficient customer base of turbine manufacturers (a large proportion of which are based in Germany).[36] The wind sector has a relatively mature supply chain and although there are a few companies involved, UK involvement is minimal. In the nuclear sector, the UK has some capability, including the three Rolls Royce manufacturing sites, which are dedicated to nuclear component production, and according to the National Metals Technology Centre (NAMTEC), "some UK companies are world leaders in the supply of equipment to overseas nuclear industries."[37] In the wave sector, UK based component suppliers are expected to emerge as the technology reaches commercialisation. There is, therefore, some capability in regard to components but this is constrained in some sub-sectors by the lack of development elsewhere in the value chain.

2.3.8 Manufacturing

The UK was one of the first countries to develop wind turbine technology in the modern era and had a relatively strong position in the market in the 1980s. However, as the market reached commercialisation in the 1990s, other countries like Denmark took the lead by adopting more business friendly approaches.[38] The UK has a history of being strong in the research phase, but then failing to benefit as the market develops, with, for example, a currently weak position in the large scale wind sector. The UK has a stronger position in the microgeneration value chain: there are 18 UK based small scale wind manufacturers and UK manufacturers are the world's largest exporters of small wind systems.[39] In the marine sector, a small number of main contractors are becoming involved, although the technology remains at a non-commercial stage of development. As noted previously, industry participants in this study voiced strong concerns over the ability of the manufacturing industry to exploit the potential gains from low carbon energy generation over the next decade.

> *"Any large scale manufacturing will have to take place overseas because the UK just don't have the manufacturing capability anymore." (Stakeholder interview)*
>
> *"We could end up buying our machines back from Taiwan or Korea and have no indigenous [manufacturing] industry thus making the same mistakes we made with wind in the 1970s. The resource is here, we absolutely know we will need the energy, the technology is being developed to harvest the energy... we have a choice to make as to whether that is British technology or somebody else's. I would argue that the scale of the opportunity and the need to ensure security of supply of energy means that this must become a UK priority... I would expect that the manufacture of a lot of the machines themselves, after the first few machines, might end up being done overseas. We could still do it ourselves, but we chose to largely emasculate our engineering industry some years ago so we could have quite a struggle to do that, but the prize of jobs, knowhow and wealth creation makes it worth trying."*
> *(MD, European Marine Energy Centre)*

[36] BWEA (2009) Powering the Green Economy
[37] NAMTEC (2009) The Supply Chain for a UK Nuclear New Build Programme
[38] REA website (see: http://www.r-e-a.net/power/wind-power/UK_market) Last accessed 1st December 2009.
[39] BWEA (2008) Small Wind Systems

However, Clipper have recently announced plans to manufacture the world's largest prototype turbine blades in the UK and there is evidence of that Siemens is considering locating a new manufacturing in the UK to take advantage of growth in the off-shore wind market.[40]

2.3.9 Installation

Overall, there is some capability in the installation phase of the value chain. The UK has a strong capability to install on-shore turbines but is somewhat limited in relation to the logistics of off-shore installation. UK ports have been involved in the installation of the majority of wind projects installed off-shore to date, but there are issues in relation to land use in the vicinity of ports and the level of investment in the overall ports infrastructure. Furthermore, the installation market for off-shore is becoming increasingly competitive. In the microgeneration sector, not surprisingly, given the nature of the sector, UK plumbers and electricians are responsible for the majority of installations. There are examples of overseas companies supplying their own expertise for some technologies like Ground Source Heat Pumps (GSHP), but this appears to be limited. There have been no new nuclear installations since Sizewell B in the late 1980s, although the UK has existing nuclear engineering capability. What is more, there are plans to develop new nuclear plants within the UK, which are due to will come on line by 2030. However, a degree of uncertainty remains regarding the actual number of new builds which will go ahead.

2.3.10 Operation and Maintenance (O&M)

In the off-shore wind sector, maintenance is an emerging industry because the majority of existing turbines are covered by manufacturer's warranty. However, some manufacturers (including Vestas) have a small number of maintenance personnel based in UK ports. The number of Independent Service Providers in both the on-shore and off-shore wind sectors is expected to grow throughout the maintenance lifecycle. In the nuclear sector there are a significant number of people employed in this segment of the value chain to operate and maintain the civil nuclear fleet. The present scale of microgeneration deployment means that maintenance activities are relatively small scale at present. The operation of microgeneration technologies will be the responsibility of the owners/ consumers and therefore is unlikely to lead to any direct employment. Due to the early stage of development of the marine and CCS sub-sectors there is little to no direct employment in operations and maintenance of these technologies.

[40] Business Green website, 22nd September 2009 (See: http://www.businessgreen.com/business-green/news/2249852/siemens-mulls-uk-wind-turbine)

2.4 Current employment in the low carbon energy generation sector

Using a number of secondary data sources, we have estimated a figure for total direct employment in the sector of approximately 30,000 low carbon generation jobs including the microgeneration sector.[41] These estimates are based on our analysis of a number of publications for each sector and have been tested with sector and industry experts. Given the lack of official, national statistics however, these estimates should be considered as an 'informed best guess'.[42] Further detail on the estimates for each of the sub-sectors is provided in the chapters which follow. Table 3 shows the breakdown of this estimated direct employment across each sub-sector.

Table 3: Direct employment in the UK Low Carbon Energy Generation Sector in 2007/08

Sub-sector	Employment estimate
On-shore wind	3,000
Off-shore wind	1,000
Marine	500
CCS	0
Nuclear	24,000
Microgeneration	1,000
Total	**29,500**

Source: PwC analysis of stakeholder interviews and a desk based review of secondary data sources, including: AEA (2008) Future Value of Coal Carbon Abatement Technologies to UK Industry; Bain & Co. (2008) Employment opportunities and challenges in the context of rapid industry growth; Cogent (2008) Energy Skills: Opportunity and Challenge. A Response to the Energy White Paper; the Guardian(2009) Britain's only wind turbine plant to close, 28th April 2009 (Available at www.guardian.co.uk/business/2009/apr/28/vestas-wind-turbine-factory-close); and SQW (2008) Skills and employment in the wind, wave and tidal sectors.

Table 3 shows current employment is driven primarily by employment within the nuclear and wind sub-sectors. The types of jobs which make up this employment are shown in Table 6 and Table 11 and cover a range of engineering and technical roles.

The lack of relevant national statistics has led us to draw upon the much broader economic classification of electricity, gas and water in order to present a statistical profile of the sector in terms of employment, workforce demographics and skills. We have, however, used other secondary data sources for the sub-sectors where available to deepen our analysis. These, more detailed, findings for each sub-sector are presented in Chapters 3-7 of this report.

[41] This figure includes employment in the construction and installation of low carbon energy generation infrastructure.

[42] Overall, and as we have noted, there is a lack of national data on the UK low carbon energy generation sector. This is due, in part, to it being a relatively new sector, but also to uncertainty around what constitutes a 'green job'. The question often posed to us in the course of this research was, for example, whether, if a plumber spends up to 50 per cent of their time installing solar panels, should they be included in the sector's workforce statistics? The complexity of the sector is also reflected in the number of Sector Skills Councils with a remit for the low carbon energy sector. If this is to become a priority sector for the UKCES and the Government in general, then further work is required to define the sector and to design and develop more comprehensive and rigorous data sources for future planning

This has the effect of including industries beyond the scope of this research, such as electricity generated from fossil fuels, as well as providing natural gas, steam supply and water supply through a permanent infrastructure (network) of lines, mains and pipes. This statistical analysis (detailed in Annex A) portrays an industry which is:

- **Male dominated** (i.e. over three quarters of employees are male compared to just over half of UK total employment);
- **Highly skilled** (i.e. almost 40 per cent are educated to NQF Level 4 or 5 compared to the UK average of around a third); and
- **Oriented towards senior/skilled jobs** (i.e. managerial, professional or skilled occupations make up 52 per cent of employment in electricity, gas and water compared to just 40 per cent of UK employment).

Interviews with key stakeholders and an analysis of existing research confirm that the profile of the low carbon energy generation workforce is similar to that of the wider sector in the above respects. What is more, the wind and nuclear sub-sectors face the additional pressures of an ageing workforce.

This combined with a perceived lack of a defined career path and less competitive salaries, in relation to traditional energy generation industries, could cause recruitment and retention issues.[43] The sector will need to address its image if it wants to attract and retain a highly skilled workforce in the future. For example, if companies want to attract the most qualified staff they cannot run the risk of alienating female candidates by being seen as a male dominated industry. However, it should be acknowledged that some stakeholders felt that the sector had a positive image among graduates.

2.5 Current unfulfilled skills needs

A recent report by IPPR suggested that there are currently four categories of skills needs in the low carbon sector, these are:[44]

- **Specific skills shortages** (e.g. high integrity pipe welders and civil engineers);
- **Skills gaps** (e.g. training plumbers to install a solar thermal heating system);
- **Generic skills gaps** (e.g. management and leadership skills); and
- **Generic green skills** (e.g. an understanding of how to reduce carbon emissions).

[43] EU Skills (2007) Occupational and Functional Map Renewable Energy Sector
[44] IPPR (2009) The future's Green: Jobs and the UK low-carbon transition

The fourth element is less relevant to the sector, which is by definition already low carbon. Table 4 therefore focuses on the current skills shortages and gaps (specific and generic) which have been identified within the sector itself. A high level summary of this table is presented in the Executive Summary of this report (see Table 1). Table 4 provides more detail and splits out skills shortages and skills gaps.

Due to the relatively small scale of deployment of marine and CCS technologies in the UK, an analysis of skills shortages or gaps in these sub-sectors has not been performed. As we have noted, these sub-sectors are primarily at the R&D phase of the value chain and the majority of new jobs are therefore likely to be in R&D in the foreseeable future. It is likely therefore, that the issues surrounding the supply of STEM graduates will also apply to marine and CCS.

Table 4: Skills shortages and gaps

Technology	Skills shortage	Specific skills gap	Generic skills gap
Wind	• Business Development Managers with a degree or Masters in engineering and additional project management skills. • Project Managers who are qualified engineers with responsibility for managing either the development or the construction process. • Mechanical Engineers with a postgraduate qualification in engineering. • Electrical Engineers who are qualified to design and construct the high-voltage connections between the wind farm and the National Grid. • Structural Engineers with a postgraduate qualification in engineering. • Turbine technicians with the skills and qualifications required to operate inside the nacelle of a wind turbine. • Geologists. • Civil engineers. • Aeronautical engineers. • Post-graduate level STEM specialists • Engineering technicians qualified to NQF Level 3 or 4	Marine engineers	Management and leadership skills
Nuclear	• 33% deficit of people qualified at NQF Levels 2 and 3	Highly skilled and experienced personnel- driven by retirement attrition	
Microgeneration		Plumbers trained to install microgeneration technologies	

Source: PwC analysis of stakeholder interviews and a desk based review of secondary data sources, including: Bain & Co. (2008) Employment opportunities and challenges in the context of rapid industry growth; EU Skills (2007) Occupational and Functional Map Renewable Energy Sector; and IPPR (2009) The future's Green: Jobs and the UK low-carbon transition.

2.6 Current skills provision in low carbon energy generation

The sector's reliance on STEM skills has been noted. The increasing demand for STEM skills in the UK and internationally is well-documented and is expected to become more acute as, from school level, fewer students opt for these subjects. This, of course, creates a vicious circle, with shortages in the teaching supply for STEM subjects already reported across developed countries (OECD, 2005).

There are already a number of specialist courses in the UK relating to the low carbon energy generation sector. These range from short courses for skilled trades (e.g. the installation of solar hot water systems for experienced plumbers/ heating engineers) to postgraduate qualifications (e.g. a Doctorate in Energy and Sustainability). Our stakeholder interviews indicate that university courses in the renewables sector are currently oversubscribed, despite the fall in the number of people studying engineering as a whole. The number of courses devoted to low carbon energy generation might be expected to increase as the industry grows and preferred operating methods are developed.

There is also the opportunity to transfer skills from other industries within the UK (e.g. off-shore engineering skills from the oil and gas industry) and abroad (e.g. knowledge of how to transport CO2 from the US enhanced oil recovery industry).

Some stakeholders were also of the view that there was a lack of cohesion in the current training for the sector and that this could be improved in future through the involvement of established trade bodies which would provide increased credibility to the resulting accreditation(s). The BWEA is working with employers to develop occupational standards and apprenticeship frameworks for the industry. There is also the opportunity, when planning future training provision for low carbon energy generation, to create regional hubs in certain areas. For example, setting up regional hubs for training on marine energy generation technologies in the South West of England and Scotland, because these will be key locations for this sub-sector.

Other stakeholders stated that training in low carbon technologies should not be aimed at creating a discrete and new sector, but should also be appropriate to address the needs of appropriately skilled individuals within the existing workforce. For example, it was thought that training and/or certification schemes on the installation of solar thermal technologies should not impose overly bureaucratic admission criteria because this will, in fact, make them less accessible for qualified plumbers who are acting as sole traders.

3. Industry insight: wind

Chapter summary

Estimates of the level of employment in the UK wind sector vary widely. Our view is that employment is currently relatively small scale with only around 4,000 directly employed in the sector.

Employment is weighted towards system integration and installation (32 per cent), and maintenance and operations (28 per cent) than it is towards manufacturing (18 per cent) or other activities. This represents the nature of the value chain of activities in the UK; a sector that has considerable potential for an increase in on and off-shore turbine installation, but which no longer has a major turbine manufacturer present. With the closure of the Vestas plant in the Isle of Wight, 500 manufacturing jobs have been lost. This is likely to have had a detrimental effect on employment in downstream component suppliers to Vestas, but we have not attempted to quantify the impact of the closure given our focus on direct rather than indirect jobs in the sector.

Employment is higher in the on-shore wind sector than off-shore, with 75 per cent of employment located in the former. However, the UK has the highest potential in Europe for off-shore wind, suggesting that off-shore-related jobs could increase rapidly. As the sector grows there will be implications for jobs downstream; these will not necessarily be turbine manufacture, but are likely to be related to the infrastructure that will be necessary for the sector to flourish and could include employment in marine construction (to further develop the port infrastructure) and employment in electrical engineering (for the design and construction of the high-voltage connections between wind farms and the National Grid).

Within the value chain there is a wide array of jobs, from degree and post-graduate acoustic and design engineers, construction project managers, wind turbine technicians and production engineers and operatives. This diversity of employment creates a need for courses from a short industry course in wind turbine technology to a Masters or Postgraduate Diploma in Renewable Energy. This variety of tailored skill requirements needs to be recognised in terms of training provision within the sector.

Identified skills shortages within the sector include:

- Mechanical and electrical engineers with a postgraduate qualification;
- Structural Engineers with a postgraduate qualification;
- Turbine technicians with the skills and qualifications required to operate inside the nacelle of a wind turbine;
- Geologists, civil engineers, aeronautical engineers; and
- Project managers with an engineering qualification.

There are currently over 50 specialist training courses ranging from postgraduate qualifications awarded by universities to part-time vocational courses run by private training providers. The university courses appear to be popular, but there are concerns regarding the supply of technicians with NQF Levels 2 or 3.

3.1 Introduction

Wind turbines can be installed either on-shore or off-shore, although the technology for on-shore installations is currently at a more advanced stage of development. On-shore wind turbines have been extensively deployed across the world, leading to a reduction in the cost of on-shore wind power by over 80 per cent since the 1980s.[45] The off-shore turbine market is at an earlier stage of development and requires a higher level of support through the Government's Renewables Obligations scheme. Several UK research projects are underway to reduce the cost of off-shore technology, and in the future, although off-shore turbines are likely to be relatively more expensive as a result of the increased technical complexity, the technology is likely to be cost-efficient.

Off-shore wind turbines use fundamentally the same technology as the on-shore variants, but the design needs to be strengthened to resist the harsher climatic conditions. The advantage of off-shore wind is that the wind speeds are higher and more consistent (off-shore turbines generate electricity up to 70-90 per cent of the time).[46] The potential for off-shore wind energy is currently limited by the immaturity of deep water turbine technology, but as research advances, wind farms are expected to be developed at greater distances out to sea.

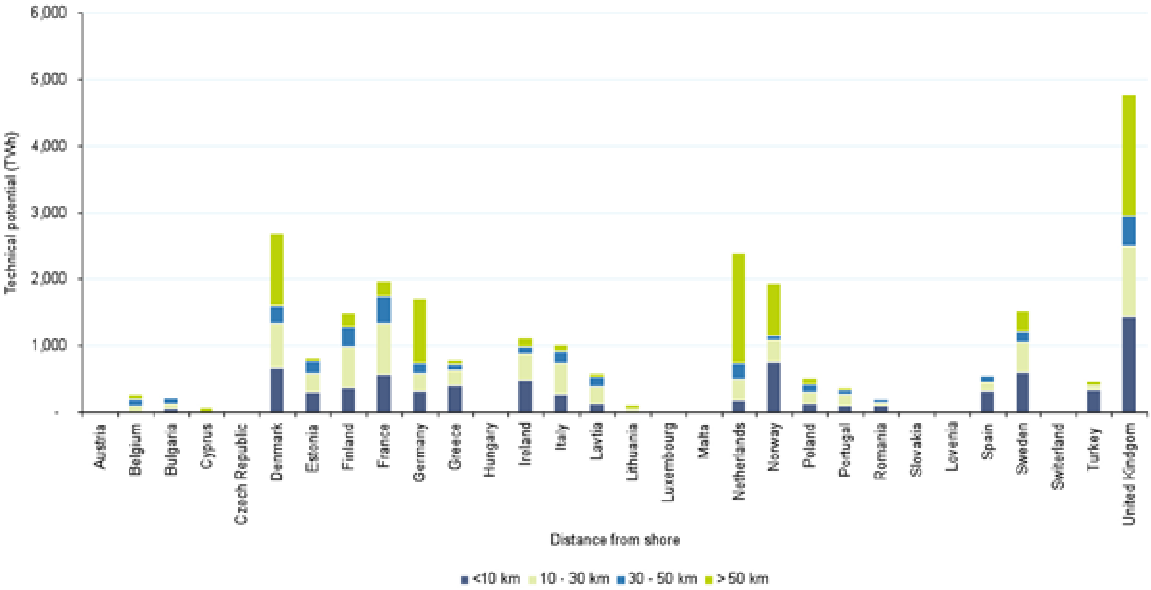
3.1.1 The UK's natural wind resources

The UK has some of the best wind resources in Europe. A recent EEA study estimated that the UK has the technical potential for 4,800 TWh of off-shore wind energy in 2030, significantly more than Denmark which ranked second with 2,700 TWh.[47] However, this perspective considers unrestricted potential and is forward looking, taking into account advances in turbine technology. Enviros and Green-X (specialist consulting firms) estimates for current off-shore wind energy potential range from 67 to 1,000TWh.[48] Considering current UK energy consumption is approximately 340TWh per year[49], wind energy has the potential to be a key energy source in the long term.

Figure 6 illustrates that the UK has the highest unrestricted technical potential in Europe. The unrestricted potential is the raw potential of the wind before social and environmental considerations are taken into account. This, therefore, includes sites currently under biodiversity protection, sites constrained by public opposition and other constrained sites in shipping lanes, military areas and tourist areas.

[45] Earth Policy Institute website, 4th March 2008 (see: http://www.earthpolicy.org/index.php?/indicators/C49/)
[46] EWEA (2009) Wind Energy – The Facts
[47] EEA (2009) Europe's on-shore and off-shore potential
[48] BERR (2007) Energy Markets Outlook
[49] DECC (2009) Digest of United Kingdom Energy Statistics

Figure 6: EEA estimates of the technical potential of off-shore wind energy in 2030 (unrestricted)



Source: EEA (2009) Europe's on-shore and off-shore wind energy potential

On-shore wind potential is estimated at 40TWh by both Enviros and Green-X. Within the UK, the highest wind speeds are in Scotland, although speeds throughout the UK are generally high relative to other European countries. The EWEA data suggest that that the majority of the UK is in the top two categories for wind speed across each of the five different topographic conditions: sheltered terrain; open terrain; coast; open sea; and hills and ridges.

3.2 Current state of the wind industry

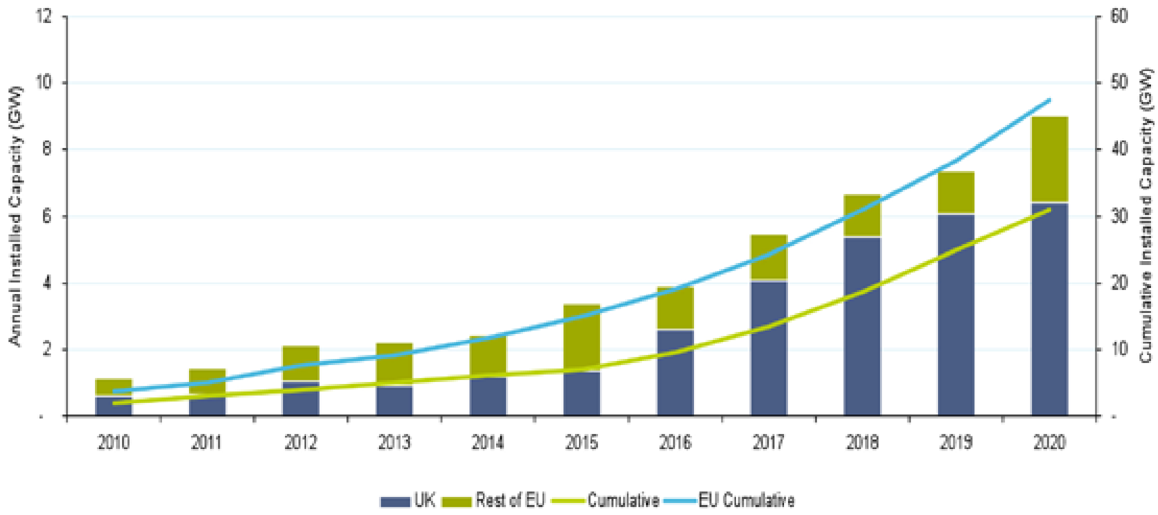
Wind turbines with over 100GW of capacity worldwide are now commonly available.[50] Installations have historically been concentrated in the on-shore sector and, by 2007, approximately 60 per cent of the worldwide cumulative installations were located in Europe. In 2008, there was 2.8GW of on-shore capacity in the UK, and 0.6GW of off-shore capacity.

The off-shore wind market is still developing, with around 2GW of installed capacity globally, but with over 100GW of projects in planning (although this includes those simply proposed by developers or in government proposed development zones).[51] The UK is currently the world leader for off-shore capacity.[52] The 0.8GW installed off-shore to date represents about 40 per cent of global capacity, with one Government projection suggesting there will be in the region of 13GW, depending on the progress of the Crown estate offshore programme.[53] However, there is potential for off-shore capacity

[50] EWEA website, 1st April 2008 (see: http://www.ewea.org/index.php?id=60&no_cache=1&tx_ttnews%5Btt_news%5D=1311&tx_ttnews%5BbackPid%5D=1&cHash=539de831ad)
[51] EWEA (2009) Oceans of Opportunity
[52] EWEA (2009) Oceans of Opportunity
[53] HMG (2009) UK Renewable Energy Strategy

to significantly exceed this target, since 25GW is planned for the third round of the Crown Estates off-shore wind programme alone. EWEA forecasts suggest the UK will represent a significant share of European off-shore capacity to 2020 (as shown in Figure 7). However, this estimate for UK capacity significantly exceeds the 13GW installed capacity estimate for 2020 which was alluded to in the Government's Renewable Energy Strategy.

Figure 7: Projected annual and cumulative off-shore installations to 2020



Source: EWEA (2008)

BWEA data suggest there is 20GW worth of on-shore and off-shore wind schemes at various stages of development in the UK. There is approximately 4GW currently installed, 8GW under construction and 9GW awaiting approval.[54]

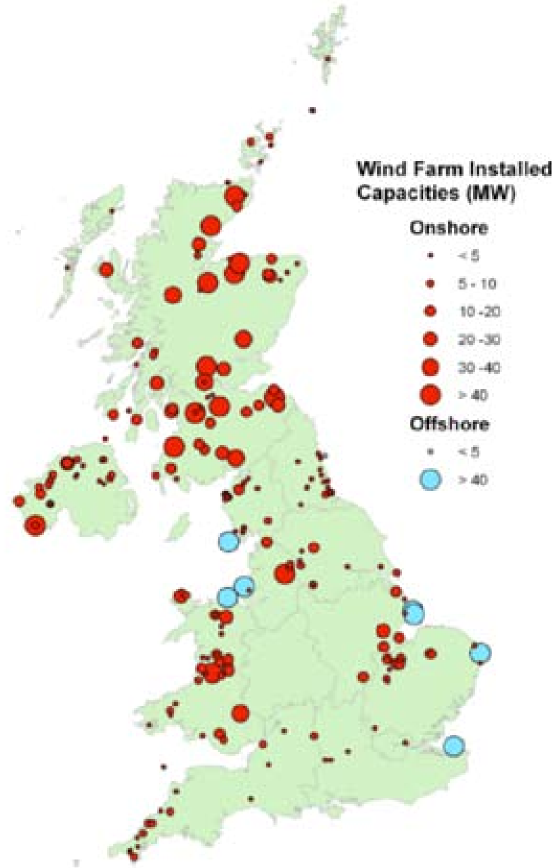
Innovas have estimated the UK wind market to be worth £11.5bn to the UK economy, and there are an estimated 5,841 companies in the sector. This research also suggests the UK is a net exporter of wind technology, with £1.4bn in exports and £0.8bn in imports in 2007/08.[55]

3.2.1 Regional variations in wind energy generation

The majority of wind installations to date in the UK have been located on-shore in Scotland, and the current pipeline indicates this trend is likely to continue. In contrast, in the off-shore sector the majority of proposed developments are located in England. Figure 8 illustrates that the majority of the on-shore projects to date are located around Scotland where the wind speeds are generally higher.

[54] BWEA (2009) Powering a Green Economy
[55] Innovas (2009) Low Carbon and Environmental Goods and Services: an industry analysis

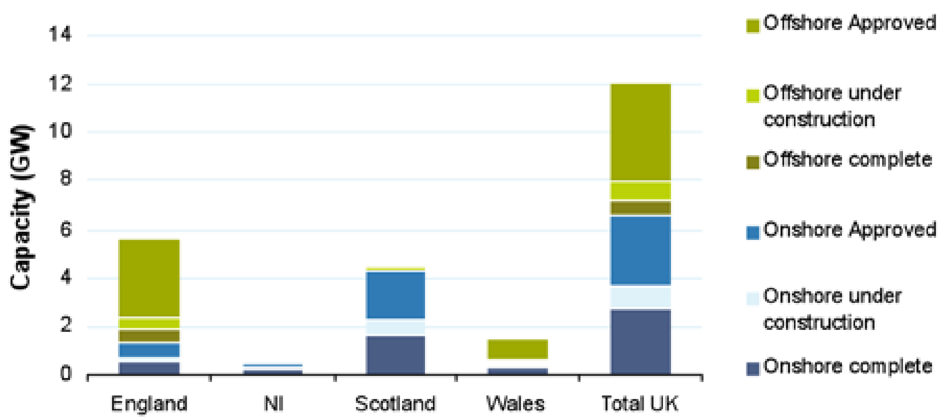
Figure 8: Installed wind farm capacity



Source: Restats (Dec 2008)

Figure 9 depicts the current UK installed wind capacity and pipeline, including sites that are under construction and those which have been approved but not yet built.

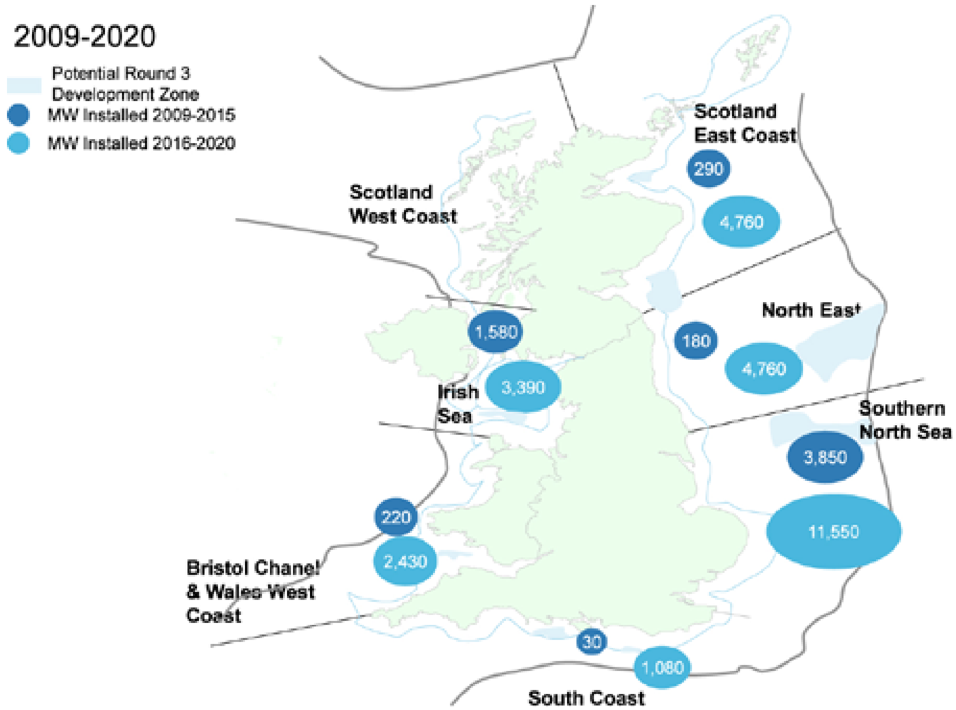
Figure 9: UK Installed Wind Capacity with Pipeline (2009)



Source: IEA (2009)

The majority of the new off-shore wind turbines are expected to be located in England. A significant share of the investment is expected to be located around the Thames Gateway region, particularly during the period 2009-15, as show in Figure 10.

Figure 10: Proposed UK Off-shore Wind Capacity (2009-20)



Source: DECC (2009)
Note: Excludes projects in Scottish and Northern Irish territorial waters

3.2.2 Potential growth in wind energy generation

Off-shore wind is the key growth area, with capacity expected to grow from less than 0.6GW in 2008 to approximately 13GW in 2020. On-shore wind capacity is also expected to grow strongly, with capacity increasing from 2.8GW in 2008 to around 14GW in 2020 according to the Government's Renewable Energy Strategy. The off-shore wind market is perceived to have the greatest potential amongst renewables in the UK, and although forecasts vary, the Carbon Trust suggests 29GW of capacity off-shore and 11GW on-shore is feasible by 2020.[56]

The Crown Estate owns the majority of the seabed out to the twelve nautical mile territorial limit, and approximately 55 per cent of the foreshore (the area between high and mean low water).[57] The Crown Estate was inundated with expressions of interest from wind farm developers after challenges emerged in obtaining planning permission on-shore. The Crown Estate is the process of operating a three round off-shore wind licensing programme which involves identifying strategic areas,

[56] Carbon Trust (2009) Off-shore Wind Power: Big Challenge, Big Opportunity
[57] Crown Estate Website (see: http://www.thecrownestate.co.uk/our_portfolio/marine.htm), last accessed 1st December 2009

reviewing proposals from developers, granting leases for new projects and even co-investing with project developers. The third round is currently in the tendering process and results are expected in December 2009.

Round 1 was a pilot round to enable developers to gain the relevant experience: it led to the award of lease agreements to 18 companies. In December 2003, a further 10 companies were awarded leases for 15 sites totalling 5.4-7.2GW in the second round of the process. Off-shore wind capacity is expected to grow significantly in the third round, with an additional 25GW planning on top of the 8GW from Rounds 1 and 2. Construction for round three farms is expected to start in 2014, with the first sites operational from 2016. Round three will also involve sites that are further off-shore (up to 170km) and at an increased depth (up to 60m).

3.3 Current employment in the wind industry

According to the Innovas report commissioned by BERR, total employment in wind is around 88,000[58] including supply chain jobs. In our view, this is an optimistic estimate given that, according to national statistics, total employment in all electricity generation and the manufacture of engines and turbines in the UK in 2007 was 50,000.[59] A recent report published by Bain & Company estimated that approximately 5,000 people in the UK were employed in wind, wave and tidal energy generation in 2007/08,[60] with on-shore wind accounting for around 70 per cent of this employment (i.e. 3,500 jobs).[61] This is supported up by preliminary results from the British Wind Energy Association study which points to the existence of 4,000 to 4,500 direct jobs in wind[62], including employment in developers, manufacturers (including R&D activity), system integrators / installers, servicing / maintenance, owners/operators and other services.

> *"Around 4/5 of the employees in wind are in the on-shore industry and 1/5 in the off-shore industry. This balance is set to change dramatically over time leading up to 2020 and beyond as off-shore wind fully takes off in terms of deployment". BWEA*

It should be noted that these figures pre-date the closure of Vestas manufacturing plant in 2009 and therefore include circa 500 manufacturing jobs which no longer exist.[63] Through a process of triangulation, we have sense-checked the findings from our desk-based review with stakeholder interviews and have therefore estimated the total current employment in wind to be 4,000 jobs, with wave and tidal energy generation accounting for around a further 500 employees.

[58] Innovas (2009) Low Carbon and Environmental Goods and Services: an industry analysis

[59] The production of electricity (SIC code 40110) - which includes, but is not restricted to low carbon energy sources - accounted for 32,000 employees, whilst the manufacture of engines and turbines, except aircraft, vehicle and cycle engine (SIC code 29110) - but is not restricted to wind turbines - accounted for 18,000 employees in the UK in 2007. (Source: Annual Business Inquiry, 2009).

[60] Bain & Company (2008) Employment opportunities and challenges in the context of rapid industry growth

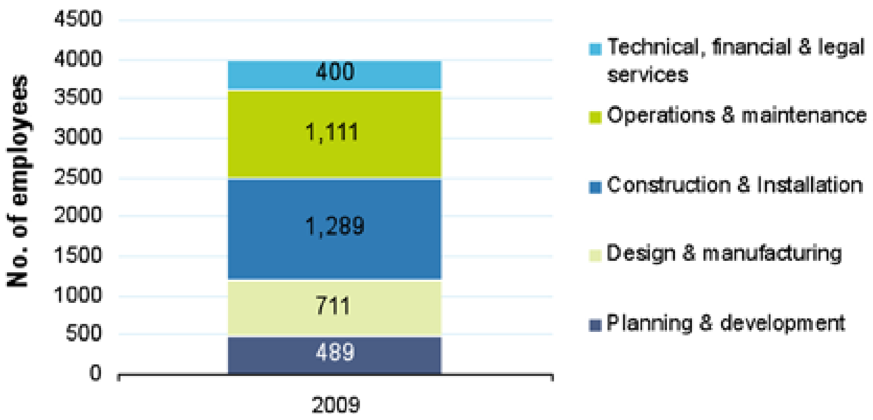
[61] EU Skills (2007) Occupational and Functional Map Renewable Energy Sector

[62] EWEA (2009) Wind Energy – The Facts

[63] The Guardian website, 28th April 2009 (see: http://www.guardian.co.uk/business/2009/apr/28/vestas-wind-turbine-factory-close)

Figure 11 provides a breakdown of the estimated 4,000 employment in wind energy generation. It shows construction and installation jobs make up around a third of this employment (32 per cent), followed by operations and maintenance and design and manufacture (representing 28 per cent and 18 per cent of employment respectively. Planning and development and technical financial and legal services account for around a fifth of total employment across these sub-sectors.

Figure 11: Proportion of workforce by job function for wind energy generation in 2009



Source: PwC analysis of SQW (2008) Skills and employment in the wind, wave and tidal sectors

The current dominance of on-shore wind over off-shore wind jobs (i.e. making up three quarters of total employment) is likely to reduce in the future because off-shore wind technologies represent greater opportunities for future growth in UK low carbon energy generation. To put this into context, the UK Low Carbon Industrial Strategy[64] estimates that the UK off-shore wind market has the potential to employ 40,000 (including indirect jobs). What is more, as off-shore wind and marine technologies are located further from the National Grid than on-shore wind farms the employment created in infrastructural developments will be on a larger scale:

> *"There is a multiplier effect to off-shore wind investment because if the UK invests in off-shore wind, it creates jobs and leads to investment on the mainland too because of the grid connection requirement." PwC renewables team*

As Germany and Denmark are already well established as manufacturers of wind turbines, the resulting increase in off-shore wind employment is likely to be mainly within construction, installation, operations and maintenance jobs.

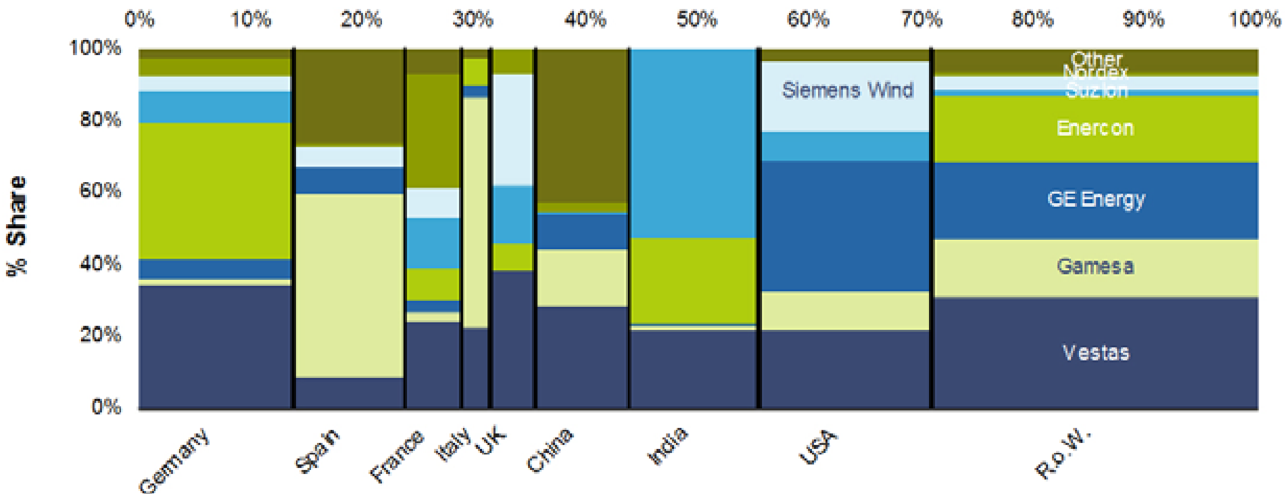
[64] HM Government (2009) The UK Low Carbon Industrial Strategy
[65] BWEA (2009) Powering a Green Economy.

3.3.1 The Wind industry value chain

The on-shore wind value chain is now relatively developed, with established international competitors. This is especially pronounced in the turbine manufacturing stage, where several large competitors dominate the market with significant market share. In contrast, the off-shore value chain is still in a development phase as relatively few off-shore turbines have been deployed to date. The BWEA suggests that "up to 75 per cent of the value chain of off-shore wind projects is addressable by UK firms with relatively low barriers to entry but capturing the remaining 25 per cent will require assembly of turbine nacelles in the UK and a strong domestic component supply chain.[65]

The following chart illustrates that the turbine manufacturing market is highly concentrated and the top five turbine competitors control 80 per cent of the global market. The competitive nature of the market and the high initial investment required to establish a footprint in the market may limit the potential for a UK company to enter the turbine market, although opportunities exist in other areas of the value chain, as discussed below.

Figure 12: Share of installed capacity by region (2006)



Source: BTM Consult, Merrill Lynch

A significant proportion of the global wind value chain has traditionally been concentrated in Denmark, Germany and Spain where rapid capacity growth was driven by supportive government policies. The dominance of these three countries has reduced as a result of new manufacturing facilities in emerging markets like China and India, and because many wind related operations are local in nature (operation & maintenance, engineering etc). Figure 13 presents the wind industry value chain.

Figure 13: The wind industry value chain

	Developers	Component suppliers	Manufacturers	System integrators	Installation	Servicing / maintenance	Owners / operators
Overview	• Locating sites and securing necessary planning and regulatory approval • Large variation in approaches, from pure development to Development with a view to ownership	• Supply components and services for Turbine manufacturer • e.g. rotor blades, towers, gearboxes, generators, etc	• Turbine Manufacture • Foundation • manufacture • Some manufacturers offer an engineering, procurement, installation and commissioning (EPIC) option • R&D	• Responsible for assembly and supply of wind turbines from 6,000-8,000 component parts	• Construction, installation of the turbine and connection to the national grid • Significantly more complex with offshore turbines. Foundation designs are still being researched • 2nd highest value part of offshore supply chain behind turbines	• Day to day repairs and maintenance. Offered by turbine manufacturer or specialist service providers • O&M can make up to 25% of the cost/kwh over the life of the turbine	• Responsible for the control and sale of electricity generated by wind farms • Historically, owners tended to be independent power providers (IPPs) and financial investors

Source: PwC analysis of stakeholder interviews

Running across each aspect of the wind farm value chain is the need for technical, financial and legal services; in the following sections, we have employed the term wind/renewables services for these professional services. Similar roles might be expected to develop in other renewable value chains once these sub-sectors reach maturity. Table 5 maps the job functions outlined earlier onto the wind farm value chain. Each aspect of the wind farm value chain is described in the paragraphs which follow.

Table 5: Mapping job functions onto the wind farm value chain

Stage of value chain	Job function	Direct employment in 2009	% of sub-sector employment
Developers	Planning and development	489	12%
Component suppliers(1)	n/a	-	-
Manufacturers (including research, development , design and manufacturing activities)	Design and manufacturing	711	18%
System integration & installation	Construction and installation	1,289	32%
Servicing/maintenance & owners/operators	Operations and maintenance	1,111	28%
Wind/renewables services	Technical, financial & legal services	400	10%
	Total wind	**4,000**	**100%**

Source: PwC analysis of stakeholder interviews and SQW (2008) Skills and employment in the wind, wave and tidal
Note: (1) Component suppliers have been excluded from our analysis of employment and subsequent scenarios because they relate to indirect, rather than direct employment.

3.3.2 Developers

In Europe, one of the most apparent trends in wind farm developments has been the increased involvement of utilities companies. In the UK, all the major electricity utilities (including E.ON, RWE, EDF and Scottish Power), have wind energy in their portfolios. Planning and development roles, such as acoustic consultants and geologists currently account for around 500 jobs[66] in the UK.

3.3.3 Manufacturers (including research and development)

Research and development continues to be an important sector to the developing wind market, and the UK has a strong position in this segment. The TSB is currently supporting off-shore wind research projects into the manufacture of cost effective turbine foundations, innovative production for off-shore rotor blades, high-power direct drive semiconductor generators, monitoring devices, stealth blade technology and a deepwater wind farm demonstrator project. Furthermore, Project Deepwater, a UK based collaborative project between BAE, CEFAS, EDF Energy, Romax and SLP Energy is in the process of designing a 5MW floating off-shore turbine for deep-water deployment.

[66] PwC analysis of SQW (2008) Skills and employment in the wind, wave and tidal sectors

The UK value chain for manufacturing and components needs to be considered in the European context because there are a number of established European players such as Vestas, GE, Gamesa, and Enercon, which dominate these segments of the value chain. The UK has a weak presence in on-shore turbine manufacturing. Clipper (a US based company) is the only competitor with a UK presence following the closure of the Vestas plant in the Isle of Wight in April 2009. Vestas suggested their decision to close the plant was a result of the reduced demand in the UK caused by planning permission complications. In the off-shore market, turbine manufacture is dominated by six global manufacturers (Siemens, Vestas, REpower, BARD, Multibrid and Nordex). Recent press reports suggest Siemens are considering locating a production facility in the UK to capitalise on growth in the off-shore wind market from Round three of the Crown Estate programme.[67]

Before the closure of Vestas, there were around 1,200 design and manufacturing jobs in the whole UK wind market[68] (excluding component manufacture). However, the closure of the site resulted in the loss of around 500 manufacturing jobs[69], reducing total employment in design and manufacturing to around 700.[70] This aspect of the value chain primarily relates to engineering, e.g. aeronautical engineers, mechanical engineers and structural engineers.

> *"The industrial base in Britain has shrunk dramatically in the past 20 years and that is a huge problem. What makes Germany successful is the high-end technical expertise to match market needs. Above all the market demands quality…We would love to have a partnership with a company in Britain but there just isn't one up to our standards."*
> *Managing Director, Valliant* [71]

> *"Because of the planning system, and as a result of decisions made in the 1990s, manufacturing has gone to Germany and Denmark… UK companies are not in a strong position to enter a well established supply chain that is predominantly based overseas." BWEA*

There is also evidence that major global turbine manufacturers tend to use the same supply chain (EWEA, 2007), making it more difficult for new suppliers to break into the market. The EWEA analysis of the turbine and component segments of the value chain illustrates that the majority of the major manufacturers are located elsewhere in Europe, with a focus around Germany and Denmark. If more turbine manufacturers were attracted to the UK, there could be a significant impact on growth along the value chain here.

[67] Business Green website, 22nd September 2009 (see: http://www.businessgreen.com/business-green/news/2249852/siemens-mulls-uk-wind-turbine)
[68] SQW (2008) Skills and employment in the wind, wave and tidal sectors
[69] The Guardian website, 28th April 2009 (see: http://www.guardian.co.uk/business/2009/apr/28/vestas-wind-turbine-factory-close)
[70] This figure has been derived from a number of secondary sources and validated through our stakeholder interviews. Therefore we have been unable to provide a breakdown of the employers.
[71] The Times website, 25th October 2009 (see: http://business.timesonline.co.uk/tol/business/industry_sectors/natural_resources/article6888947.ece#)

In September 2009, Clipper announced plans to establish a new facility in the North West of England to develop and manufacture a new 10MW off-shore turbine, following a £4.4m award under the EFT Off-shore Wind Demonstration Call. This turbine is amongst the largest under development, and the presence of Clipper's 10MW manufacturing facility would mean the UK had a turbine manufacturer on its shores.

Rapid growth in the European wind market has led to soaring turbine demand, and rapid scaling up of the value chain. This has led to a mixture of vertical integration and full component outsourcing strategies for components in Europe.[72] Several segments of the component value chain, including turbine blades, bearings and gearboxes, are heavily concentrated and have high barriers to entry as a result of the significant up-front investment required and the manufacturing ramp up time.[73] Towers are one aspect of the value chain which is often produced locally: these represent approximately 26 per cent of the total cost of a wind turbine, with, therefore, significant potential for UK involvement in this regard.[74]

The UK has strengths in component supply from other industries (aerospace, automotive, marine) which could be transferable to the renewables sector. Indeed, BERR suggests that there are opportunities in bearings, gearboxes, generators and transformers.[75] The potential barrier to this transfer is that these components are considered to be critical, and in this sector, experience is considered to be paramount.

The current trend of increasing turbine sizes, especially in the off-shore market may have a positive impact on the UK value chain as manufacturers are increasingly considering relocating directly to, or close to, harbour facilities to ease transportation. Further, the increasing size of foundations means that these will be built closer to off-shore wind sites.[76] This will have a knock on effect on the demand for component manufacture within the UK, thus leading to potential job creation as component manufacturers scale up their operations.

[72] Wind Energy The Facts website (see: http://www.wind-energy-the-facts.org/en/part-4-industry--markets/chapter-3-industry-actors-and-investment-trends/wind-turbine-manufacturing-trends/supply-chain-key-to-delivery.html) Last accessed 1st December 2009

[73] Wind Energy The Facts website (see: http://www.wind-energy-the-facts.org/en/part-4-industry--markets/chapter-3-industry-actors-and-investment-trends/wind-turbine-manufacturing-trends/supply-chain-key-to-delivery.html) Last accessed 1st December 2009

[74] EWEA (2007) Supply Chain: The race to meet demand

[75] BERR (2008) Supply chain constraints on the deployment of renewable electricity technologies

[76] EWEA (2009) Oceans of Opportunity; Off-shore report

3.3.4 System integration/installation

Research by the BWEA indicates that nearly half the capital cost of new wind projects is in the development and installation stages of projects, a large component of which relates to cabling and foundations.[77] The BWEA suggests that UK companies have the capability to produce the cables, and could even supply the thousands of kilometres of cable required for already planned projects. The UK also has the capability to construct off-shore structures from its experience in the North Sea oil and gas projects. This could be a significant opportunity for the UK because Carbon Trust research suggests that the installation process is the highest value segment of the off-shore value chain (representing between 40 and 50 per cent of the total costs).[78]

Installation, integration and some elements of production are closely related because global turbine manufacturers prefer to locate these stages close to the end market. The port of Bremenhaven, in Germany, for example, was re-developed for the off-shore market: and subsequently, several manufacturers (REpower and Multibrid) located their operations in the port area. Industry experts suggest that, because the wind value chain market is relatively mature, the installation aspect is a key area of opportunity for the UK.

> *"The UK has missed the boat really for large scale wind turbine manufacturing. The opportunities in the UK relate to installation, servicing, ports, vessels and substations."*
> *PwC Renewables Team*

> *"Britain's ports could become the hub of activity and economic opportunity as we massively increase the amount of renewable energy we get from our seas – and could be key to constructing and transporting wind technology."*
> *Mike O'Brien, Minister of State for Energy*[79]

There are five ports in the UK that have either been used for off-shore wind projects or have made concerted preparations for forthcoming projects.[80] The Mostyn port in Wales has been used for four off-shore wind farms, although these are smaller installations (between 60 and 90MW each). This has involved the storage of turbine parts at the port, some finishing work before the turbines are taken out on installation vessels, and also the relocation of some operation, servicing and maintenance services. International ports are also involved in the installation of UK wind projects: Esbjerg port in Denmark is current installing wind farms in the UK, including the 500MW farm at Greater Gabbard, which is the largest built off-shore to date. A potential problem in this regard is the shortage of installation vessels. This is exacerbated by the fact that, as the EWEA has indicated, there is a shortage of installation vessels in the UK.[81]

[77] BWEA (2009) Powering the Green Economy
[78] Carbon Trust (2009) Off-shore wind power: big challenge, big opportunity
[79] New Energy Focus, 31st March 2009 (see: http://www.newenergyfocus.com/do/ecco/view_item?listid=1&listcatid=118&listitemid=2439)
[80] EWEA (2009) Europe's Ports compete for new off-shore wind business
[81] EWEA (2009) Europe's Ports compete for new off-shore wind business

The nature of the UK's port infrastructure has been identified as a significant barrier to the development of the off-shore supply chain. A 2009 study by DECC indicates that, while the UK has sufficient potential port locations, manufacturers have expressed concern at not being able to find ports with sufficient capacity (including availability of land and vessels) due to lack of investment in the necessary infrastructure for off-shore wind projects.[82] Ports are required for assembly, construction of foundations, project construction, and as a base for maintenance and servicing. However, UK ports are reluctant to invest in infrastructure to support the wind market until the market is more developed. This may be an area to which the Government might wish to give further consideration in order to stimulate the wind sub-sector.

> *"Larger component manufacture needs to take place reasonably close to final market, as does product assembly, construction, and operations and maintenance." BWEA*

The installation market is increasingly challenging, with several European ports competing to win construction contracts for off-shore wind projects in UK waters. Bremerhaven in Germany has emerged as a centre for the off-shore wind supply chain and the port has the potential to supply a significant share of the installations planned for the UK. The magnitude of this threat may be amplified by the development of high speed jack-up vessels, which may therefore improve the competitiveness of ports located further from the UK.

Total employment in the construction and installation of wind farms is currently in the region of 1,300[83] and involves jobs such as fabrication engineers, construction project managers and installation engineers.

3.3.5 Servicing and maintenance

The wind servicing and maintenance market is relatively immature, with Original Equipment Manufacturers (OEMs) currently the primary service providers. Going forward, Independent Service Providers (ISPs) are expected to play a greater role throughout the maintenance lifecycle, including on-site monitoring, remote monitoring, servicing and over-haul. The EWEA has stated that such independent O&M companies will start to emerge once the market is large enough to support them.[84] The UK has a number of companies emerging in the on-shore/off-shore servicing sector including OTT Industry Services, Seacore Ltd, SLP Energy, and Insensys.

Operations and maintenance posts account for around a quarter of employment in UK wind energy generation[85], (i.e. 1,100 FTE[86]). These roles require the skills of professional engineers, turbine technicians and trading buyers. Again, these jobs will have a knock on effect on supply chain jobs:

[82] DECC (2009) UK Ports for the off-shore wind industry: Time to act
[83] SQW (2008) Skills and employment in the wind, wave and tidal sectors
[84] EWEA (2009) Oceans of Opportunity: Off-shore Report
[85] SQW (2008) Skills and employment in the wind, wave and tidal sectors
[86] Full Time Equivalents

"The wind farms also create ongoing work in servicing and maintenance. A team of 15 people employed by Vestas, for example, is based at Mostyn to provide operations and maintenance support for the North Hoyle turbines. Picking up on the demand for these skills, the port itself has recently created its own off-shore wind maintenance team."[87]

3.3.6 Wind/renewables services

The UK has several large project development companies, including Renewable Energy Systems, a McAlpine subsidiary[88] and is home to some of the leading low carbon consultancies, including Garrad Hassan, which specialises in wind, marine and solar technical services. Technical, financial and legal services make up about a tenth of employment in this sub-sector[89], (i.e. 400) and include roles such as accountants, health and safety specialists as well as technical roles such as craneage and divers.

3.4 Current skills needs in the wind industry

The following vignette describes a typical job in the operation stage of the wind value chain in 2009, the role of a Turbine Engineer. In the Scenarios section of this report, we revisit a number of 'typical jobs' to illustrate how these may evolve over the next decade.

Tell me a bit about your career to date

After graduating from Imperial College with a degree in Aeronautical Engineering I worked for Airbus designing and testing the A380 landing gear systems in the UK and France. After completing a successful flight test campaign I looked for a new and exciting challenge in the world of engineering. In the current climate one of the largest global issues is sustainable, affordable energy and RES is tackling this problem head-on. I was immediately involved in the construction of a wind farm in a remote part of Sweden, not far from the arctic circle in temperatures of -30ºC!

What does a Turbine Engineer do?

My role is now focussed on the development of turbine technology to ensure maximum safety and production throughout project lifetime. This involves regular contact with the turbine suppliers to solve technical issues

Source: RES website, Meet our People, Profile of a Turbine Engineer. (Available at: http://www.res-group.com/careers/meet-our-people.aspx, last accessed 26th November 2009)

The skills requirements for the types of occupation which make up each stage of the value chain are described in Table 6. As this Table demonstrates, the specific job role and level of skill required varies considerably from more senior roles, such as Business Development Director, which require postgraduate qualifications to lower level roles, such as site wardens, which require lower level skills (i.e. NQF Level 2). However, the majority of posts are for highly skilled staff (i.e. NQF Level 4 and above).

[87] EWEA website, September 2009 (see: http://www.ewea.org/fileadmin/ewea_documents/documents/publications/WD/2009_september/Mini_Focus_September_2009.pdf)
[88] REA website (see: http://www.r-e-a.net/power/wind-power/UK_market), last accessed 1st December 2009
[89] SQW (2008) Skills and employment in the wind, wave and tidal sectors

Table 6: Occupation and skill level within each stage of the wind farm value chain

Value chain	Function	Occupation	NQF Level
Developers	Planning & development	• Acoustic Consultants • Archaeologists • Directors (including • Business Development Director, Finance Director, Health, Safety and Risk Director, Procurement Director, Sales Director, Trading Director) • Ecologists • Geologists • GIS Engineers • Ornithologists • Planners	5
Manufacturers	Design & manufacturing	• Aeronautical Engineers • Civil Engineers • Electrical Engineers • Environmental Engineers • Mechanical Engineers • Structural Engineers	5
System integration/ installation	Construction & Installation	• Construction Project Managers • Installation Engineers	5
		• Fabrication Engineers	3
Servicing/maintenance and owners/operators	Operations & maintenance	• Professional Engineers	5
		• Business Development Managers	4-5
		• Buyer Managers • Managers(including Client Company; Deputy/ Regional; Client Company; Assistant Project Managers) • Procurement Managers • Production Supervisor • Project Development Engineers • Operations Supervisors (Client Company) • Risk Managers • Sales Managers • Senior Managers • Service Managers • Supervisors • Team Leader • Trading Buyers	4
		• Levels 1-4 Technician (Wind Operator Company) • Manufacturing Buyer • Production Control Engineer • Wind Turbine Technician (including Seniors)	3
Wind/renewables services	Technical, financial & legal services	• Accountants • Forecasting/Taxation Specialists • Health and Safety Specialists • HR Professionals	4
		• Administration Assistants • Craneage • Divers • IT Specialists	3
		• Site Wardens	2
		• Clerical and Administrative Staff	1/2

Source: PwC analysis of EU Skills (2007) Occupational and Functional Map Renewable Energy Sector & SQW (2008) Skills and employment in the wind, wave and tidal sectors

Our interviews with key stakeholders and analysis of the literature confirm that this sub-sector is currently facing skills shortages in the following areas:

- Business Development Managers with a degree in engineering and additional project management. A Masters Degree is also desirable;[90]
- Project Managers who are qualified engineers with responsibility for managing either the development or the construction process;[91]
- Geologists;[92]
- Civil engineers;[93]
- Marine and aerospace engineers;[94]
- Mechanical Engineers with a postgraduate qualification in engineering;[95]
- Electrical Engineers who are qualified to design and construct the high-voltage connections between the wind farm and the National Grid;[96]
- Structural Engineers with a postgraduate qualification in engineering;[97]
- Engineering skills to NQF Level 3 or 4 (below degree level);[98]
- Technical skills and qualifications required to operate inside the nacelle of a wind turbine (i.e. NQF Levels 2 or 3);[99]
- Post-graduate level STEM specialists; and[100]
- Senior managers and professionals with appropriate management and leadership skills.[101]

As with the Sector as a whole, the majority of roles within this sub-sector require STEM skills, specifically technical and engineering skills. In light of concerns surrounding the future supply of STEM skills within the UK, this may create future skills shortages in UK wind energy generation.

[90] EU Skills (2007) Occupational and Functional Map Renewable Energy Sector
[91] EU Skills (2007) Occupational and Functional Map Renewable Energy Sector & Bain & Co. (2008) Employment opportunities and challenges in the context of rapid industry growth
[92] cited in IPPR (2009) The future's Green: Jobs and the UK low-carbon transition
[93] cited in IPPR (2009) The future's Green: Jobs and the UK low-carbon transition
[94] cited in IPPR (2009) The future's Green: Jobs and the UK low-carbon transition
[95] EU Skills (2007) Occupational and Functional Map Renewable Energy Sector & cited in IPPR (2009) The future's Green: Jobs and the UK low-carbon transition
[96] EU Skills (2007) Occupational and Functional Map Renewable Energy Sector, Bain & Co. (2008) Employment opportunities and challenges in the context of rapid industry growth & cited in IPPR (2009) The future's Green: Jobs and the UK low-carbon transition
[97] EU Skills (2007) Occupational and Functional Map Renewable Energy Sector
[98] cited in IPPR (2009) The future's Green: Jobs and the UK low-carbon transition
[99] Bain & Co. (2008) Employment opportunities and challenges in the context of rapid industry growth
[100] cited in IPPR (2009) The future's Green: Jobs and the UK low-carbon transition
[101] IPPR (2009) The future's Green: Jobs and the UK low-carbon transition

3.5 Current provision of skills for the wind industry

Stakeholders held conflicting views on whether or not the renewables sector is an attractive sector within engineering. There are currently over 50 specialist courses in this area in the UK, ranging from postgraduate qualifications awarded by universities to part-time short courses run by private training providers.[102] Stakeholder interviews suggest that university courses in the renewables sector are currently oversubscribed, but overall engineering headcount is still declining. More of a concern for wind energy generation is recruiting technicians with the right vocational level qualifications (i.e. NQF Levels 2 or 3). The BWEA is also currently working with employers to develop occupational standards and apprenticeship frameworks.

[102] SQW (2008) Skills and employment in the wind, wave and tidal sectors

4 Industry insight: marine

Chapter summary

The marine power generation sector is still currently at a relatively early stage in its development; it is a far less well proven technology than power generation from wind.

Our estimate of direct employment in the marine sector is less than 500. Given the early stage of development of the sector, and the nature of the projects underway to prove technical and commercial viability, employment is currently limited to research and development activities, with a small manufacturing component. However it is an industry which has the potential to create direct employment in all parts of the value chain, particularly planning and design, manufacturing, construction and installation and operations and maintenance, but, which, in our view, is unlikely to create substantial levels of employment between now and 2020.

Due to the early stage of development, the current skills needs within this sub-sector are primarily in engineering research and development. However, as the technology is deployed on a larger scale, employment and the corresponding skills needs will become more diverse, and are likely to be similar to those of the in the wind sub-sector.

As with the wind sector, marine and tidal resources in the UK offer great long-term potential. Furthermore, given the very early stage of development of the marine sector, the potential exists to develop not just commercial technology, but also a manufacturing base, with the potential for downstream component supply. Assuming commercial viability, there would be a related need for electrical engineers (for the design and construction of the high-voltage connections between marine installations and the National Grid).

Specialist training courses in marine technologies are limited at present, but more might reasonably be expected in the medium to long-term as the industry grows in scale.

4.1 Introduction

The two main categories of marine energy technology are wave and tidal systems. Wave energy is created by movements of water near to the surface of the sea caused by winds blowing over the surface. In contrast to tides, which move the entire body of water, waves move the area close to the water surface. There are a range of Wave Energy Convertors (WECs) currently in development to capture wave energy, including oscillating water columns, overtopping devices, attenuators and point absorbers

Tidal energy is generated from the kinetic movement of the sea as tides come in and out. As with wave technology, there are a number of different tidal designs in development which generally fall into either the barrage or off-shore groups. Tidal stream devices include tidal stream turbines, reciprocating tidal stream devices, venture effect tidal stream devices. Tidal range systems are similar in principle to hydropower, involving barrages across estuaries with a high tidal range, and include tidal barrage and tidal lagoon systems.

4.1.1 The UK's natural marine resources

There is significant potential in marine energy, with an estimated global resource of between 8,000 and 80,000 TWh per year in wave energy and approximately 800TWh per year for tidal energy, compared to world electricity consumption of 16,000TWh (Soerensen & Weinstein, 2008).[103] The UK has a strong marine (wave and tidal) resource, which, according to the REA, represents 50 per cent of Europe's wave energy resource and 35 per cent of its tidal resource.[104] The Carbon Trust suggests that wave and tidal energy combined could supply up to 20 per cent of the UK's current electricity demand.[105] Figure 14 illustrates the level of wave power in the UK relative to other locations in Europe.

[103] Soerensen & Weinstein (2008)
[104] REA website, 23rd September 2009, (see: http://www.r-e-a.net/info/rea-news/0909REA_NEJointStatement/)
[105] Carbon Trust website, 22nd September 2009 (see: http://www.carbontrust.co.uk/News/presscentre/marine-energy-funding.htm)

Figure 14: Average annual worldwide wave power

Source: Pelamis, cited in Carbon Trust (2009)
Note: Chart illustrates average annual wave power in kilowatts per metre of crest width for various sites around the world

4.2 Current state of the marine industry

Marine renewable energy is an emerging industry and there are a large number of different devices currently being developed. At the end of 2008, there were an estimated 76 wave devices under development and many of these were still at an early stage.[106] Several UK companies have now tested large scale demonstrators at the European Marine Energy Centre in Orkney, and Pelamis, a UK company, was the first company worldwide to deploy marine technology on a commercial scale, although this project, in Portugal, is currently non-operational.

The UK is recognised as a leader in the global marine market. The £72m invested in the wave sector from 2004-08 represents about half of the investment worldwide; a quarter of all wave developers have UK operations; and the European Marine Energy Centre (EMEC) and the New and Renewable Energy Centre (NaREC) are located in the UK.[107] Wave Hub is a new off-shore facility being planned for the Cornish coast which will provide an area of sea with grid connection and planning consent for testing devices once they have been tested as prototypes in other locations (like EMEC in Orkney).

[106] Carbon Trust (2009) Focus for success: a new approach to commercialising low carbon technologies
[107] HMG (2009) The UK Low Carbon Industrial Strategy

The UK Government has supported the industry with various funding mechanisms including Renewables Obligations[108], the Marine Renewable Deployment Fund,[109] and the recently announced Marine Renewables Proving Fund (a £22m scheme) which will support projects at an earlier stage of development. a £22m scheme.

There are only a few systems deployed UK at the moment as the industry is still in a research and demonstration phase. Demonstrations have focused on small-scale devices, with a view to scaling up the technology once the prototypes have been proven to be successful, however, the Carbon Trust has suggested that the marine sector could enter an early mass deployment phase around 2015.[110] In April 2009, there was 0.5MW of wave energy and 1.45MW of tidal stream installed in the UK, as illustrated in Table 7. However, several participants in this research thought that this may be overly optimistic.

Table 7: Current marine devices installed in the UK

Technology	System Installed	Location	Capacity (MW)
Wave	Wavegen Limpet	Scotland	0.5
Tidal	Open Hydro Open-Centre turbine (Testing)	Scotland (EMEC)	0.25
	Marine Current Turbines (MCT) SeaGen	Northern Ireland	1.2

Source: BWEA (2009)

The BWEA believes the majority of the early marine projects in the UK will be located in Scotland as a result of the higher level of financial support available in that jurisdiction. The European Marine Energy Centre, which is recognised as a global leader in testing marine technology is located in Orkney. In addition, many of the leading marine developers have operations in Scotland, including Aquamarine Power, AWS Ocean Energy, Hammerfest UK, Pelamis Wave Power, Scotrenewables and Wavegen. The Scottish Government is keen to develop a marine manufacturing industry in Scotland and is offering an award of £10m to the team that successfully demonstrates marine energy systems. There is an estimated 14GW of potential wave capacity and 7.5GW of tidal power capacity in Scotland: the Scottish Government is currently proposing to leverage this potential capacity by offering three Renewables Obligation Certificates (ROCs)[111] for tidal stream devices and five ROCs for wave energy devices, compared to the two currently offered elsewhere in the UK.[112]

[108] In the 2009 budget, offshore wind was granted support of approximately £525m under the ROC scheme

[109] The Marine Renewable Deployment Fund, established in 2004, has a budget of £50m, but there have been reports that businesses have experienced difficulties in accessing this fund (see www.guardian.co.uk/business/2009/jul/19/utilities-energy-marine-power-uk)

[110] Carbon Trust (2009) Focus for success: a new approach to commercialising low carbon technologies

[111] The Renewables Obligation is the main support scheme for renewable electricity projects in the UK. It places an obligation on UK suppliers of electricity to source an increasing proportion of their electricity from renewable sources. A Renewables Obligation Certificate (ROC) is a green certificate issued to an accredited generator for eligible renewable electricity generated within the United Kingdom and supplied to customers within the United Kingdom by a licensed electricity supplier. One ROC is issued for each megawatt hour (MWh) of eligible renewable output generated. The Renewables Obligation Order came into effect in April 2002, as did the Renewables Obligation Order (Scotland). The Renewables Obligation (Northern Ireland) Order came into effect in April 2005. These Orders have been and are subject to regular review. The Orders place an obligation on licensed electricity suppliers in England and Wales, Scotland and Northern Ireland to source an increasing proportion of electricity from renewable sources. In 2005-06 it was 5.5 per cent (2.5 per cent in Northern Ireland). In 2006-07 the obligation is set at 6.7 per cent (2.6 per cent in Northern Ireland).

[112] New Energy Focus website, 29th April 2009 (see: http://www.newenergyfocus.com/do/ecco/view_item?listid=1&listcatid=119&listitemid=2568)

The value of the UK wave and tidal market was estimated at £73m in 2007/08, with about £27m from manufacturing activities and approximately £7.3m from exports.[113] Estimates by the Carbon Trust suggest the marine sector could generate between £300m to £900m by 2030 and between £600m and £4.2bn by 2050, depending on the pace of development.[114]

4.2.1 Growth in the UK marine market

A recent BWEA study (October 2009) reported that industry opinion suggests that, by 2020, there could be between 1 and 2GW of marine energy projects installed.[115] Marine technologies are considered to be a technology for the medium- to long-term and significant capacity growth is expected until around 2030. One forecast by the Carbon Trust suggests in its 'mid case' that capacity in the UK could reach 2GW in 2030, before increasing to 30GW in 2050.[116]

The proposed Severn Trent tidal range project has the potential to significantly increase the share of UK energy from marine technology and the River Severn accounts for 80 per cent of the potential tidal range resource in the UK.[117] In addition, the £21bn Cardiff-Weston Barrage option has the potential to generate up to 5 per cent of the UK's electricity. A decision is expected in 2010 and the project could be operational by 2018, if a smaller scale option is selected, or after 2020 if a larger scale solution is chosen.

4.2.2 Current employment in the marine industry

A review of secondary data sources and our stakeholder interviews suggest that current employment in marine energy generation in the UK is limited (i.e. circa 500), and these jobs are primarily in research and development. The relatively early stage of development of marine technologies means that there is unlikely to be a significant growth in employment by 2020. The types of jobs created are likely to be in planning and design, construction and installation and operations and maintenance.

The majority of manufacturing jobs are likely to be located outside of the UK, However, successful collaboration between universities and industry in the UK could maximise the potential growth in jobs within this sub-sector, by anchoring some value added component manufacture within the UK.

4.3 The UK Marine Value Chain

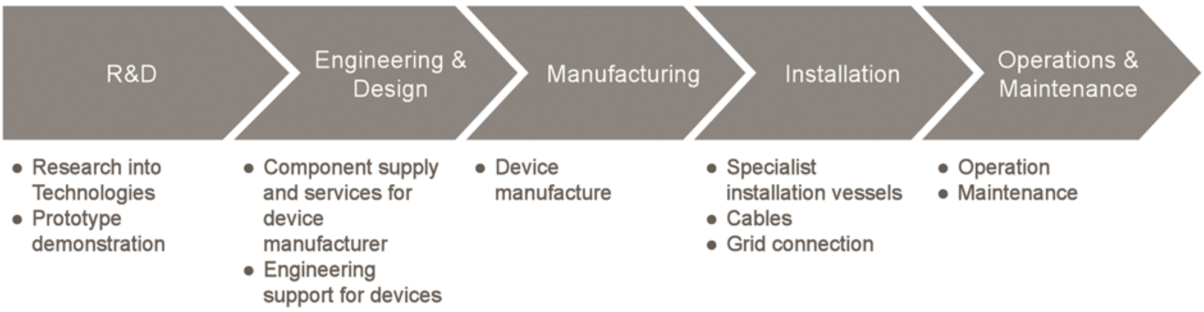
The Carbon Trust report[118] cited above assessed the potential for value chain in the UK from the marine sector: its analysis suggested the UK was well positioned to become the "natural owner" of marine technology. The Trust reported that the UK could have 80-90 per cent market share of the

[113] Innovas (2009) Low carbon and environmental goods and services: an industry analysis
[114] Carbon Trust (2006) Policy Frameworks for Renewables
[115] BWEA (2009) Marine Renewable Energy: State of the Industry Report
[116] Carbon Trust (2009) Focus for success: a new approach to commercialising low carbon technologies
[117] Institute of Mechanical Engineers website, (see: http://www.imeche.org/about/keythemes/energy/Energy+Supply/Renewable+energy/Marine+energy/Tidal+Power/), last accessed 1st December 2009
[118] Carbon Trust (2009) Focus for success: a new approach to commercialising low carbon technologies

value chain shown as a result of the strength of UK companies, its leading position in research, and UK manufacturing successes in similar industries (including oil and gas, and shipping).[119]

Please note, given the stage of development of this sub-sector, all jobs (around 500) are currently in the R&D phase of the value chain presented in Figure 15.

Figure 15: Marine Value Chain



Source: PwC analysis of Focus for Success: A New Approach to Commercialising Low Carbon Technologies. Carbon Trust (2009)

4.3.1 Research and development

The UK has 24 marine research facilities (primarily based at universities) which is the highest concentration of R&D capacity in the world. The UK also has two of the world's leading marine test facilities: the European Marine Energy Centre (EMEC) in Orkney and the New and Renewable Energy Centre (NaREC) in Northumberland. A third testing facility, Wave Hub, is planned for the Cornish coast in 2010. Wave Hub is a new pre-commercial demonstration centre and will become Britain's first low carbon economic area, focused on marine energy demonstration, manufacture and servicing.

4.3.2 Engineering and design

A significant proportion of the leading device developers are located in the UK and the Carbon Trust Marine Energy Accelerator is supporting the development of the component value chain.[120] The strengths at the research stage of the value chain combined with the reputation of UK companies in developing new devices should give the UK a strong position for engineering and design. There are approximately 30 device developers headquartered in the marine and sectors in the UK, about 15

in the rest of Europe and approximately 20 elsewhere in the world.[121] UK companies in the wave and tidal sectors include Pelamis, HydroVenturi, AWS Ocean Technology, Ocean Power Technologies, Open Hydro, Wavegen, and Lunar Energy.

[119] Carbon Trust (2009) Focus for success: a new approach to commercialising low carbon technologies
[120] Carbon Trust (2006) Policy Frameworks for Renewables
[121] EEF (2008) Delivering the low-carbon economy

The EEF has stated that there are two key areas of opportunity for UK businesses from the marine market; developing industry standard devices and specialist products for niche markets.[122] The strength of UK businesses in the market means there is a real potential for industry standard devices to be developed in the UK. Niche systems will also need to be designed to incorporate into coastal or off-shore infrastructure. An example of this is a project in Spain to incorporate wave devices into a breakwater.

4.3.3 Manufacturing

The UK Government is proposing an additional £10m investment for the New and Renewable Energy Centre (NAREC) which would enable developers and component manufacturers to test components on-shore to improve efficiency and reliability. This is likely to increase the likelihood of components being developed in the UK, either by UK or overseas component manufacturers. Scotland is expected to be the focus for marine installations in the near future (as discussed above) and the Scottish Government is taking an active role in developing the Scottish marine value chain. A significant share of design, manufacture and assembly may well therefore be retained in the UK.

The Carbon Trust suggests that the body of the marine device is likely to be built close to the assembly point, noting that the UK has expertise in power take off systems, but that mass components like moorings and control systems are unlikely to be built in the UK.[123]

4.3.4 Installation

The UK has dry dock facilities from its history in the oil and gas sector which can be used in the marine sector. There is currently a shortage of installation vessels (crane and heavy lift barges), and in the period leading up to 2020, there will be increasing competition from the off-shore wind sector. Different technologies have different installation requirements and until devices reach the deployment stage of the lifecycle on a larger scale, the investment required in installation infrastructure is unlikely to be forthcoming.

4.3.5 Operation and maintenance

The operations and maintenance sector is still relatively undeveloped, but is expected to emerge as the more wave and tidal farms are deployed. The UK can draw on its experience maintaining oil and gas facilities off-shore in the North Sea.

[122] EEF (2008) Delivering the low-carbon economy
[123] Carbon Trust (2009) Focus for success: a new approach to commercialising low carbon technologies

4.4 Current skills needs for the marine industry

The current skills needs of this sub-sector are primarily in research and development of marine technology. The stakeholders who participated in this research were of the view that specific future skills needs will be dependent on the development of the marine value chain in the UK. There was a consensus however, that as with the other sub-sectors, STEM skills will be crucial and future skills requirements in of the sub-sector are likely to be similar to that of the wind sub-sector i.e. highly reliant on STEM skills, with a range of posts and skills levels including civil engineers, electrical engineers, mechanical engineers and structural engineers, educated to NQF Level 5, supervisors and managers with Level 4 qualification and technicians with NQF Level 3. It could also be assumed that the more generic skills identified in the other low carbon sub-sectors, such as project management, will also be important to marine industry.

4.5 Current provision of skills for the marine industry

Scotland and the South West of England are likely to be important regions for marine technology. The South West was recently designated as a Low Carbon Economic Area specialising in wave and tidal power,[124] thus providing the opportunity for creating regional hubs for skills development.

More specialist training provision might be expected to emerge when large scale deployment occurs and the industry is able to refine and develop preferred operating methods.

[124] HM Government (2009) The UK Low Carbon Industrial Strategy

5. Industry insight: carbon capture and storage

Chapter summary

Estimates of direct employment in the carbon capture and storage (CCS) sector in the UK vary. Our view is that employment is currently negligible.

Given the early stage of development of the sector, employment is currently in research and development. However, given the UK's current reliance on fossil fuel power generation, and the capacity to store a significant volume of CO2 in the depleted gas fields and oil fields in the North Sea, this is, again, a sector with considerable potential for growth.

While skills required will be specific to particular technologies, the fundamental disciplines will be very much the same as those for other power generation sectors, and for the off-shore oil industry. Skill requirements will include high level qualifications in process, power and design engineering, and knowledge and skills related to the UK's off-shore storage infrastructure.

The demand for technology transfer skills will increase as the technologies develop and greater university-industry collaboration is required to facilitate the transition from demonstration and deployment. There will, in due course, be a need for legal and financial advice, and economists.

There is the potential to transfer skills from other industries. For example, the technological skills required for shipping and transporting CO2 could be transferred from the UK beverage industry (potentially a short-term solution) and from the UK and US oil industries (particularly production and petroleum engineering skills related to enhanced oil recovery. Off-shore engineering skills from the UK oil and gas industry could be used to build new or modify the existing infrastructure necessary for CO2 storage sites. Also the extensive knowledge of the UK's depleted oil and gas reservoirs that currently exist within the oil and gas industry will be invaluable to the development of the sector.

Some estimates exist for the long-term employment potential of CCS assuming the technology is actively deployed in fossil fuel power stations. Estimates indicate that UK employment in CCS could reach 30,000[125] and that these jobs will be in design and manufacture.

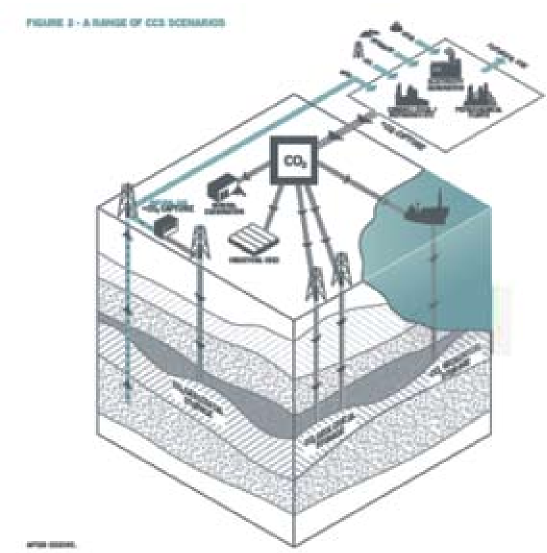
On balance, given the early stage of development of the sector, the potential for growth, and the depth of expertise in related UK industries, our view is that the UK could become a leader in CCS in the long-term, with the ability to export services and expertise. However, the sector is unlikely to create substantial levels of employment between now and 2020.

[125] AEA (2008) Future Value of Coal Carbon Abatement Technologies to UK Industry

5.1 Introduction to the technology

Carbon Capture and Storage (CCS) or Geosequestration is a process for capturing and storing up to 90 per cent of CO2 emissions from power stations and industrial sites. It is, possibly, the only option for reducing greenhouse gas emissions while continuing to use fossil fuels using our existing energy distribution infrastructure.[126] CCS is considered to be a medium-term solution for abating fossil fuels because it is not renewable, so alternative solutions will be required for the long-term.[127] CCS reduces the CO2 of reliable sources of energy (coal and gas), however, the process can be very energy intensive and can require between 10 per cent and 40 per cent of power stations capacity to scrub and transport CO2, which is likely to cause electricity price rises.[128]

Figure 16: Principles of CCS



Source: Global CCS Institute

[126] Cooperative Research Centre for Greenhouse Gas Technologies website (see: http://www.co2crc.com.au/dls/factsheets/CO2CRC_FactSheet_01.pdf), Last accessed 1st December 2009

[127] Environment analyst website, 14th October 2009 (see: http://environment-analyst.com/2286)

[128] British Geological Survey website, (see: http://www.bgs.ac.uk/education/carboncapture/PostCombustionCoalFiredPowerPlant.html), last accessed 1st December 2009

5.1.1 The CCS process

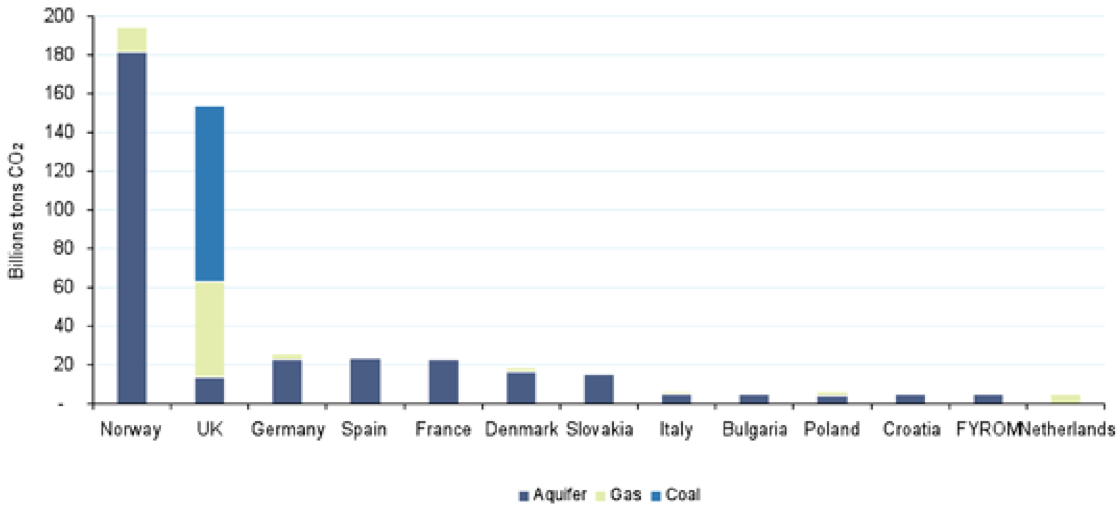
Once developed and proven on a commercial scale, carbon capture technology will be retrofitted to fossil fuel power stations and industrial sites to remove the CO2 from the power station emissions. The point sources would be connected in clusters to a pipeline that would then take the CO2 emissions across the country to off-shore locations, where it would be injected under pressure into former oil or gas fields or deep aquifers. Alternative transport methods include road tanker and by ship. The CO2 is stored beneath a layer of impermeable rock. The final stage is monitoring using seismic and geochemical equipment to verify that there is no leakage.

The net CO2 reductions of carbon capture can be improved if CCS is deployed in conjunction with biomass co-firing. This technology uses biomass material in place of a proportion of the coal used in existing plants to reduce carbon emissions, and the process requires minimal modifications if the biomass fuel content is less than 10 per cent.

5.1.2 The UK's natural resources

The UK's large capacity for CO2 storage gives it a strong natural advantage in the CCS market, and there is potential for the UK to store CO2 captured in Northern European countries. The UK has more storage space for CO2 than all other Northern European countries combined (with the exception of Norway).[129] A study by Dr Haszeldine, a leading CCS researcher, suggests the UK controls sandstone rock formations beneath the sea which have the capacity to store 150bn tonnes of CO2 (equivalent to hundreds of years of CO2 output from UK power stations).[130] The British Geological Survey have made an initial estimate of the gross capacity of 292 sinks in UK waters as 24.7bn tonnes of CO2 and a £3.5m project was announced in October 2009 to evaluate the potential of UK sites for CO2 storage.

Figure 17: UK CO2 storage potential



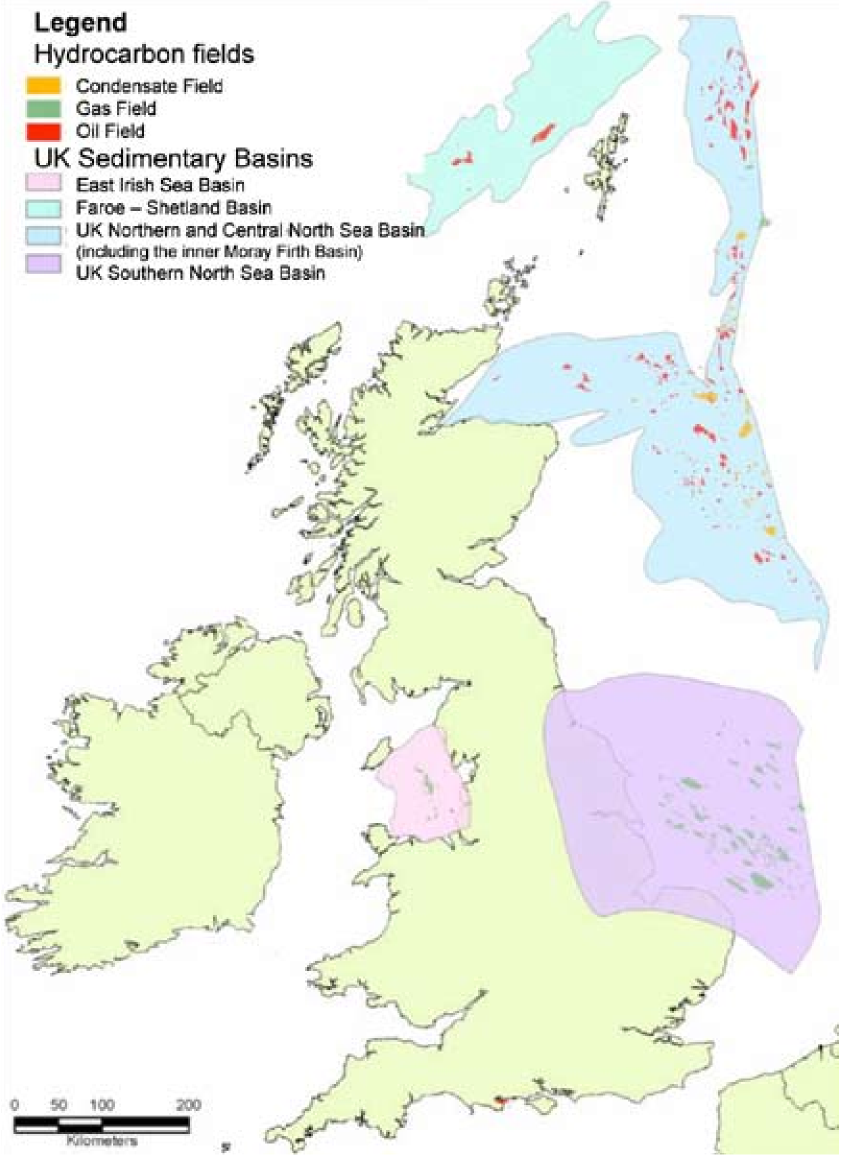
Source: SCCCS (2009)

[129] The Times website, 8th September 2009 (see: http://www.timesonline.co.uk/tol/news/environment/article6826247.ece)

[130] The Times website, 8th September 2009 (see: http://www.timesonline.co.uk/tol/news/environment/article6826247.ece)

The highest concentration of CO_2 sinks is located close to the Humber.[131]

Figure 18: Location of potential CO2 storage locations



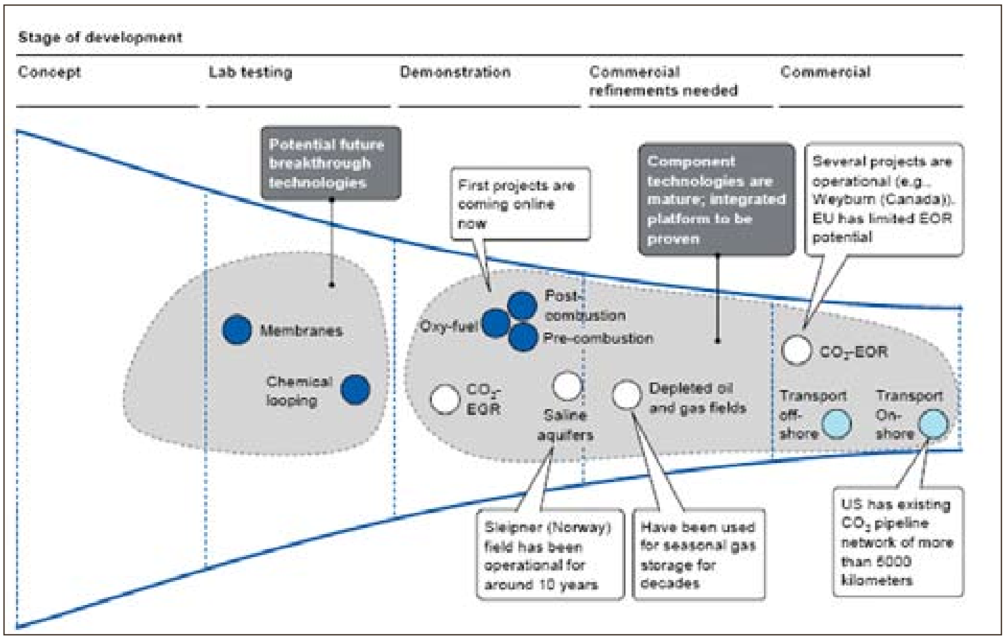
Source: ACCAT (2009)

[131] BER R (2007) Development of a CO2 transport and storage network in the North Sea

5.2 Current state of the CCS industry

The different phases of CCS (capture, transport, storage and monitoring) are already in use around the world. The vital next step is to prove the total process works on a commercial scale when all the different components are brought together, and to confirm the safety and effectiveness of the CO2 storage. Figure 19 illustrates the various phases in the CCS process.

Figure 19: Stage of CCS component technologies (2008)



Source: Mckinsey (2008)

There are three methods of carbon capture currently under research: post-combustion capture; pre-combustion capture; and oxyfuel combustion. The technology for post-combustion has been demonstrated in full scale gas-fired power plants and in a number of coal-fired pilot plants. There are approximately ten larger demonstrator plants under construction globally for operation to 2012. In October 2009 the European Commission announced plans to invest around £165m in developing a CCS scheme at Hatfield Colliery near Doncaster.[132]

The UK competition (see below for further details) for a 300MW plant would be the largest demonstration of post combustion capture on a coal fire plant. Pre-combustion technology is very close to commercialisation and some developers are already consenting large gas CCGT plants that are 'coal conversion ready'. Oxyfuel combustion has not been used for carbon capture historically, but several large international companies are researching its applicability to CCS, including Vattenfall, Babcock & Wilcoxes and the UK based Doosan Babcock.

[132] BBC News website, 19th November 2009 (See: http://news.bbc.co.uk/1/hi/england/south_yorkshire/8368688.stm)

Pipelines are a proven means of transporting CO2 and in the US, there are more than 5,000km of pipelines for transporting it for Enhanced Oil Recovery (EOR). In the UK, existing oil or gas pipelines could potentially be upgraded to carry CO2, but this is an area which requires further research. The high pressure injection of CO2 underground and storage is also a relatively proven concept, although concerns remain about the potential for leakage and the health implications of this. In the US, CO2 has been injected into oil fields for years in the Enhanced Oil Recovery process to force oil to the surface.

The UK Government launched the Carbon Capture competition in November 2007 with the aim of having a post-combustion demonstration plant online by 2014. In addition to this, in April 2009, plans were announced to fund up to three other coal CCS demonstrators. In April 2009, the Government announced that all new carbon combustion power stations producing 300MWe or more would need to be "carbon capture ready".

In the Ernst and Young CCS country attractiveness near term index, which ranks countries which are planning to accelerate the deployment of demonstration CCS plants through direct subsidy (released in the first quarter of 2009), the UK is ranked number two globally, although in the long term index, they are ranked fifth.[133]

Shell, the National Grid and Scottish Power have formed a consortium to submit a bid for the UK Governments CCS competition, with the intention of delivering the UK's first commercial size CCS coal fired station. The other two projects involve a proposed new E.ON plant at Kingsnorth and an RWE project in Tilbury. However, E.ON announced in October 2009 that it is deferring its investment decision in CCS for two to three years as a result of the recession and falling energy demand. Some uncertainty around Government plans for CCS technology may well also be a factor in discouraging investment. To qualify for the Government's competition, entrants were expected to develop a 3/400MW plant by 2014. The CEO of E.ON UK, Paul Golby, has suggested that the 2014 deadline could be waived, but there are some suggestions that the £1bn project will be delayed as a result.[134]

In October 2009, Ed Miliband, the Secretary of State for Energy and Climate Change, announced that the UK may bring forward plans for a levy on electricity bills to fund CCS demonstrators.

> *"We are determined to go as far and as fast as we possibly can with CCS…that's why we are planning to bring forward legislation for a levy to fund projects and that is going to provide a clear financial mechanism to make the projects happen."*
> *Ed Miliband, Secretary of State for Energy and Climate Change*

There is also significant potential for CO2 storage in UK waters and recently, the UK and Norway joined forces to build a profile of the North Sea to assess the potential for CO2 storage. This study

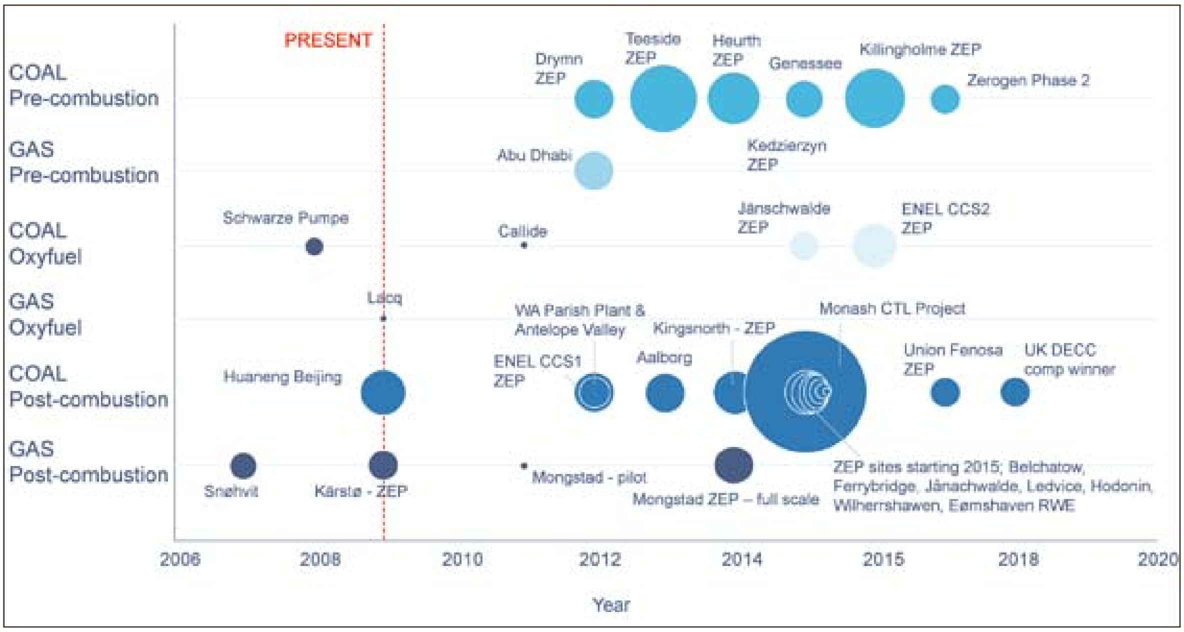
[133] Ernst and Young (2009) Carbon Capture and Storage Country Attractiveness Index
[134] The Times website, 12th October 2009 (see: http://business.timesonline.co.uk/tol/business/industry_sectors/utilities/article6870284.ece)

will assess network issues and is expected to propose methods for managing CO2 flows across borders. Further, and as noted above, a £3.5m project was announced in October 2009 to evaluate the potential of UK sites for CO2 storage.

The International Energy Association has stated that 850 full scale CCS plants will need to be built by 2030, with 100 of them online by 2020 if the world is to halve CO2 emissions by 2050, as fossil fuels are expected to remain a dominant source of energy into the future.

The Scottish Centre for Carbon Capture and Storage (SCCCS) believes that the current UK CCS Programme will not produce the demonstration plants before 2020. Its view of rival projects worldwide suggests that this will be too late for the UK to gain a competitive advantage because the US is progressing rapidly and China intends to have two demonstration plants operational several years before the UK. At the current rate of progress, the SCCCS notes that the UK will be behind the USA, Australia, Canada and the China in this regard.

Figure 20: Current CCS Projects in development (2009)



Source: Scottish Centre for Carbon Storage (2009)
Note: Bubble size relates to annual tonnage of CO2 projected to be stored.

The US Government has already awarded $3.5bn to CCS projects. The US Energy Secretary announced in October 2009 that the US could have 10 demonstration plants by 2016, and that the technology needs to be ready for global deployment by 2017-19.[135] Norway announced at the Carbon Sequestration Leadership Forum in October 2009 that it is planning to raise annual CCS investment to a record $621m in 2010 in line with its ambition to lead international efforts in CCS development.

[135] Reuters website, 13th October 2009 (see: http://www.reuters.com/article/rbssUtilitiesElectric/idUSLD36126020091013)

The CCS is currently at an early stage in the development cycle and current value generated in the UK is primarily related to research and development for the proposed UK demonstration plants. Scientists suggest the North Sea could provide the UK with a resource worth up to £10bn per annum if it is exploited as a CO2 store, as the UK could sell licenses to other European countries, including Germany, Denmark and Poland. This could be worth up to £5bn a year according to estimates. This approach has already been taken in Texas, which markets itself as 'the CO2 sink for the USA'. In addition, the market for storage technology could be worth between £3bn and 5bn per year. AEA estimates for the potential value of the CCS industry to the UK are presented below in Table 8.

Table 8: AEA Projections for the value of CCS technology to the UK

Category	Business/activity	UK GVA (£bn/yr)		
		2010	**2020**	**2030**
New coal generation plant (including CCS where fitted)	Project management	0.13	0.16	0.25
	Engineering (e.g. design)	0.29	0.35	0.52
	Manufacturing/procurement	0.46	0.55	0.82
	Construction	0.07	0.11	0.18
	Commissioning	0.07	0.10	0.17
	Financial & legal services	0.05	0.07	0.18
	Total new plant	1.08	1.34	2.12
CCS retrofits to existing generating plant	Project management	0.00	0.01	0.12
	Engineering (e.g. design)	0.00	0.01	0.18
	Manufacturing/procurement	0.00	0.02	0.33
	Construction	0.00	0.00	0.09
	Commissioning	0.00	0.00	0.06
	Financial & legal services	0.00	0.01	0.11
	Total CSC retrofitting	0.00	0.05	0.90
Consultancy	Feasibility projects	0.00	0.01	0.01
CO_2 storage	Management of storage sites[1]	0.00	<0.01	0.01
Biomass co-firing		0.03	0.02	<0.01
Total GVA (£bn/yr)		1.12	1.42	3.05
CSS related jobs		0	2,097	25,003
Total CAT related jobs2		**18,410**	**23,689**	**50,825**

Source: AEA (2008)

5.3 Potential barriers to the development of the CCS industry

There are four main barriers to the successful development of the CCS industry: the availability of finance; the cost of the technology; the need to prove that the technology is viable on a commercial scale; and public acceptance of the safety of the process.

Press reports have noted that public spending for CCS demonstrators could be scaled back. The Government originally planned to support four demonstrators, but there are suggestions that only two plants will now receive funding, and that a gradualist approach will be adopted by staggering tenders to build the new plants.[136]

> *"If these reports are true they make for dismal reading. The UK Government has been a leader on CCS but is now in danger behind the pack in a race to develop this crucial technology".*
> *Luke Warren, International Policy Executive, Carbon Capture & Storage Association.*[137]

The cost to retrofit CCS technology has been estimated at £1bn per plant and the pipes to transport CO2 to its storage site is estimated at £1m per mile.[138] Although CCS is potentially one of the cheapest clean energy options, research suggests that CCS could add £28 to an average annual bill of £498.[139] Furthermore, the distance that CO2 needs to be transported to its store could have a significant impact on this cost. The high current costs of CCS equipment could be expected to decline as it is deployed globally and manufacturers benefit from economies of scale. In the short term, the development of demonstration plants may be delayed by the reduced availability of finance.

Whilst each of the key processes within CCS is already in existence, significant research is still required to demonstrate that the technology can work on a commercial scale. Geological storage has been proven for normal engineering timeframes, but storage integrity of CO2 storage sites needs to be established over a longer timescale.

> *"We have been extracting gas from the North Sea for many years and as geologists, we know that the methane or natural gas has been in these structures for millions of years. If we engineer the structures in which we hope to store our CO2 to the same level, there is no reason why they should leak and the CO2 should stay down there for millions of years."*
> *Dr Mike Stephenson, Head of Energy, British Geological Survey*

[136] The Guardian website, 23rd September 2009 (see: http://www.guardian.co.uk/environment/2009/sep/23/clean-coal-project-spending)
[137] Business Green website, 24th September 2009 (see: http://www.businessgreen.com/business-green/news/2250011/industry-warns-goverment-ccs)
[138] The Guardian website, 13th June 2008 (see: http://www.guardian.co.uk/environment/2008/jun/13/carboncapturestorage.fossilfuels)
[139] New Civil Engineer, 9th September 2009 (see: http://www.nce.co.uk/news/energy/uk-could-be-co2-sink-for-europe/5207784.article)

Public acceptance, or lack of it, may well also be a barrier to the development of the technology. In Germany, a pilot project at Schwarze Pumpe had to vent the CO2 it trapped into the atmosphere because there were local objections to its burial underground. The EU Energy Commissioner, Andris Piebalgs, stated at the Carbon Sequestration Leadership Forum in October 2009 that:

> *"There is still a lot of work needed to explain to citizens why we do this and that this is not dangerous to health and that this will not decrease the property value".*[140]

5.4 Current employment in the CCS industry

The absence of large scale CCS operations in the UK means that employment within this sub-sector to date has been limited primarily to research and development. According to Innovas (2009), total employment in CCS within the UK in 2007 was 4,600 (including supply chain jobs) and is expected to grow to 6,200 by 2015.[141] However a study by AEA projects that the number of CCS related jobs in the UK will be negligible until 2020, when it is anticipated that to[4]tal employment will be in the region of 2,000.[142] Employment is then expected to increase significantly potentially employing between 30,000 and 60,000 in the UK by 2030. Approximately 50 per cent of these jobs will be engaged in existing activities (boiler and steam turbine design and manufacture), and 50 per cent from CCS services (design and manufacture of CCS services).[143]

If the CCS projects go ahead, the major part of project management, design, construction and commissioning for projects is expected to be retained by Original Equipment Manufacturers and Engineering, Procurement, Construction contractors in the UK. It is likely that manufacturing will be outsourced to low cost countries, but some strategic manufacture may be retained in the UK.

CCS therefore represents a potential opportunity for future employment in the UK. However, it will require appropriate support mechanisms to be put in place by the Government:

> *"If the UK becomes the 'birthplace' of the CCS industry, then development work and technology expertise is more likely to be based here as well. That will create jobs within the UK in a new industry that will grow rapidly over the coming decades... If the focus of CCS development moves to another part of the world, jobs and ex¬pertise – in R&D, manufacturing, engineer¬ing and other services – will go with it." (AEA, 2008)*[144]

[140] The Guardian website, 13th October 2009 (see: http://www.guardian.co.uk/business/2009/oct/13/ed-miliband-carbon-capture-storage-kingsnorth)
[141] Innovas (2009) Low Carbon and Environmental Goods and Services: an industry analysis
[142] AEA (2008) Future Value of Coal Carbon Abatement Technologies to UK Industry
[143] AEA (2008) Future Value of Coal Carbon Abatement Technologies to UK Industry
[144] Carbon Capture and Storage Association (2009) Carbon Capture and Storage – building a low carbon economy p.13-14

Collaborations between industry and universities are likely to become more common as CCS technologies develop. Edinburgh University in particular has been active in this area. This may lead to increased demand for technology transfer officers with universities.

A range of start-up companies are beginning to emerge. For example, a new start-up company called CO2 DeepStore, which aims to sell carbon dioxide storage space within the UK.

The timing of this job creation depends on the timing and availability of Government support. One stakeholder reported that an optimistic scenario would be:

- 2014: first CCS project operational;
- 2020: four projects operational; and
- 2020s: job creation beginning to emerge.

This is in keeping with the projections outlined in the AEA report.

5.5 The UK CCS value chain

Commercial demonstration of CCS has the potential to generate value for the UK through not only creating a new industry, but also because it is likely to lead to new fossil fuel power stations being commissioned. The AEA has carried out a study to assess the potential UK share of the new coal fired power stations based on telephone interviews with market experts (Table 9). Stakeholders suggested the future value was dependant on the UK establishing an early and strong track record and reputation for successful CCS projects. The research suggests the UK will have a reasonably large share of UK projects, but that the export potential is minimal. A key area of strength for the UK is in the boiler segment of the supply chain as a result of Doosan Babcock's focus in this area. The construction and commissioning segment of the value chain is also relatively strong because these operations generally take place close to the site. The value chain for the CCS sub sector is presented in Figure 21.

Table 9: AEA estimates for UK market share of the UK Market for new coal fired power station value chain

	Project management	Engineering	Manufacturing & procurement	Construction	Commissioning
Boiler	50%	50%	25%	75%	75%
Steam Turbine	20%	10%	5%	20%	20%
Gasifier	20%	10%	5%	20%	20%
Gas Turbine	20%	10%	5%	20%	20%
Air Separation Unit	20%	10%	5%	20%	20%
Shift Reactor	20%	10%	5%	20%	20%
Carbon Capture	50%	10%	40%	50%	50%
Balance of Plant	50%	50%	40%	50%	50%
Carbon Transport	50%	50%	50%	50%	50%
Carbon Storage	35%	35%	35%	35%	35%

Source: AEA (2008)

Table 10: AEA estimates for Global market share of the Global Market for new coal fired power station value chain

	Project management	Engineering	Manufacturing & procurement	Construction	Commissioning
Boiler	5%	5%	2%	1%	2%
Steam Turbine	5%	5%	2%	1%	2%
Gasifier	4%	5%	1%	1%	2%
Gas Turbine	4%	5%	1%	1%	2%
Air Separation Unit	4%	4%	2%	1%	2%
Shift Reactor	4%	5%	1%	1%	2%
Carbon Capture	4%	5%	2%	1%	2%
Balance of Plant	4%	5%	2%	1%	2%
Carbon Transport	3%	4%	2%	1%	2%
Carbon Storage	5%	5%	2%	1%	3%

Source: AEA (2008)

Figure 21: CCS Value Chain

Fossil fuel power generation

- If CCS technology can be proven on a commercial scale, additional fossil fuel plants are likely to be approved
- Considerable coalfired capacity is expected to be decommissioned soon (from 2015) as a result of old age and the EU Large Combustion Plant Directive (LCPD)

Capture

- Research into technologies
- Demonstration
- Components Manufacture/ assembly of CCS plants
- Installation/fit out of CCS
- Servicing/ Maintenance

Transport

- Research to evaluate different transport options and potential for European networks
- Manufacture of pipelines
- Installation/ construction of pipelines and/or infrastructure for ports if CO2 is transported by ship
- Maintenance

Storage

- Exploration / capacity studies
- Site preparation
- CO2 injection

Monitoring

- Monitoring of CO2 stores

Source: PwC analysis of stakeholder interviews

5.5.1 Fossil fuel generation power stations

UK companies have historically been involved in supply of power plants as OEMs or as EPC (Engineer, Procure, Contract) contractors. All of the UK's coal fired power stations and half of the gas fired power plants were supplied by companies with UK operations including Alstom, Siemens, and Doosan Babcock. However, fossil fuel power stations have not been constructed in the UK for a long time and the UK's capacity to produce a new station has diminished.

5.5.2 Capture

Several contractors with UK operations including Doosan Babcock, Alstom, Fluor, Foster Wheeler, Air Products and Jacobs in carbon capture research. The Post-combustion capture technology is owned by foreign companies, but several of the developers have a UK partner/presence. Doosan Babcock is developing Oxyfuel firing technology in the UK.

5.5.3 Transport

The UK has capability from the Oil and Gas sector and AMEC have played a key role in several pipeline studies. Further analysis of the existing Oil & Gas infrastructure is required, but analysis presented by BERR (Element Energy, Poyry Energy and British Geological Survey) suggests the UK already has a significant amount of the necessary infrastructure in place.[145] There are already production platforms, on-shore terminals and off-shore pipelines in place in the UK, but there suitability to CCS needs to be reviewed on a case by case basis. For example, there are pipelines in place which theoretically could carry CO2, but use of the existing pipe network may be limited by their capacity for transporting CO2 under high pressure.

[145] BERR (2007) Development of a CO2 transport and Storage Network in the North Sea

5.5.4 Storage and Monitoring

There is an emerging capability in the UK for CO2 storage and several studies are underway to assess the potential for UK CO2 stores. Companies which are establishing capabilities as operators of underground storage facilities in the UK include Denbury Resources, DeepStore, Conocco Phillips.

5.6 Current skills needs for the CCS industry

There are a range of CCS specific technologies and skills that will be common for all CCS projects; however different parts of the CCS chain (capture, transport and storage) will require different skills.

> *"In general the jobs created will be high skilled, requiring process, power or design engineering qualifications or knowledge of off-shore storage and site characterisation. There will also be a demand for service sector consultancy skills to provide legal and financial advice and to advise on climate change economics. The fundamental disciplines for the sector will include maths, physics and economics." (Policy Officer, CCSA)*

Fundamental disciplines for CCS jobs will include maths, physics and economics although geology and site characterisation of depleted oil and gas wells will also be important. Increased university and industry collaboration will increase the demand for knowledge and technology transfer skills.

5.7 Current provision of skills for the CCS industry

In the short term there is the potential for skills transfer from the beverage industry, which has developed cost-competitive shipping technologies to transport CO2. However, this would only be suitable as an intermediate option because it is on a much smaller scale than would be required for CCS. If the UK is to deploy CCS on a large scale it will be necessary to develop a network of pipelines for transportation. The UK could learn from the extensive experience of transporting CO2 in enhanced oil recovery within the US.

There is likely to be a lot of migration to facilitate the sharing of CCS knowledge and intellectual property between countries, e.g. through exchange students. In the short term this will be net inward migration, but in the long term the UK will have the opportunity to share its skills and knowledge with countries like China and India, as they begin to focus on the reduction of carbon dioxide.

The UK CCS industry could make use of the skills already present in its oil and gas industry such as off-shore engineering and extensive knowledge which currently exists on its depleted oil and gas wells (in terms of structure, geology, capacity, containment measures and characterisation) for future storage potential.

6 Industry insight: nuclear

Chapter summary

In the absence of national statistics on the nuclear workforce, Cogent, as the SSC for the industry, has undertaken a significant programme of research in this area. We have drawn on this research as the most reliable available evidence base.

Direct employment in the nuclear industry is around 24,000 and indirect employment in supply chain and the construction of new builds accounts for a further 20,000. More than half of this employment is in the North West of England. The expected lifespan of the UK's current civil nuclear fleet means that a number of units are due to go offline over the next decade. This will have a knock on effect of reducing both direct and indirect employment. The scale of this reduction in the overall workforce will be heavily dependant on the volume and timing of future new builds, which could potentially require a significant volume of construction work over a relatively short timeframe. The number and timing of new builds is still uncertain.

In general the workforce is more highly skilled (to NQF Level 3 or 4) and a greater proportion of the workforce is engaged in professional and technical roles than the UK average. However, the workforce profile is also ageing faster than the UK workforce as a whole. Cogent estimates that up to 70 per cent of the current nuclear workforce will have retired by 2025. Even accounting for the overall reduction in demand, this retirement attrition has the potential to create a significant skills gap, as the most experienced personnel - often managers or senior officials - begin to retire. Effective transition planning must therefore take place to ensure that younger staff acquire the skills and expertise necessary to fill this gap. There is considerable work underway by bodies like the National Skills Academy for Nuclear and the Office for Nuclear Development to ensure that the skills and supply chain needs of the sector are met.

6.1 Introduction to the technology

The UK currently has ten active nuclear power stations, although a large proportion of the current operational civil reactor fleet is reaching the end of its life and is due to be decommissioned. Assuming no new capacity is constructed in the immediate future, Sizewell B will be the only remaining operational nuclear facility in 2023, although the life of some existing plants may be extended as a short term solution. With the assumption that a reactor has a life of roughly 40 years, three quarters of current operational reactors, (with an approximate age of 30 years) will need to be replaced by 2030.

6.2 Current state of the nuclear industry

In 2006, the Government stated that new nuclear would need to be part of the UK's energy mix in the future, but the energy review made it clear that the private sector would be responsible for funding, constructing and operating the new civil nuclear fleet.

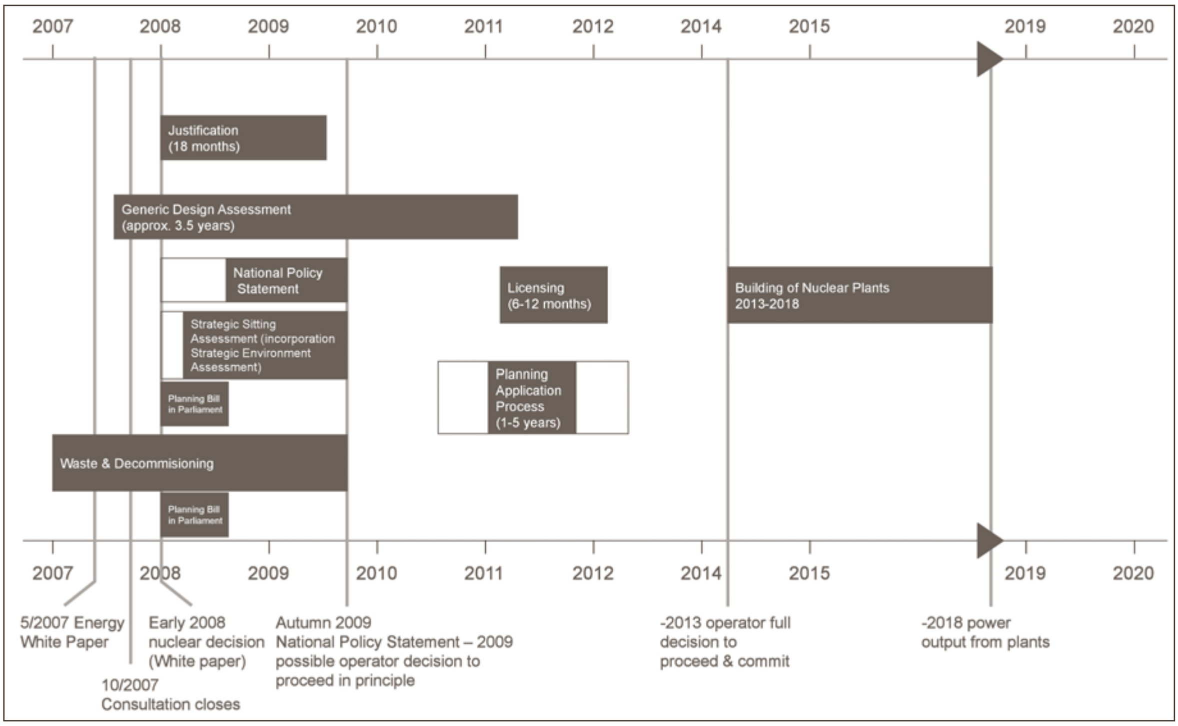
> *"Given the challenge of climate change and energy security, it is right to embrace nuclear power as one of the technologies that can serve us in the future." Ed Miliband, Secretary of State for Energy and Climate Change, October 2009*

EDF and a consortium of RWE and E.ON won the initial auctions for potential nuclear sites and have pressed ahead with plans to develop nuclear plants. EDF is planning to construct four Areva EPR plants (6.6GWe of capacity) at Sizewell C and Hinkley Point C. The RWE/E.ON consortium has stated that it will wait for the end of the Generic Design Assessment process before making a technology decision, but has plans for 6GWe (which would be either 4 Areva EPRs or six Westinghouse AP1000s). In October 2009, a consortium including Iberdrola, GDF, and Scottish & Southern announced plans to construct up to 3.6GWe, with construction starting in 2015. Assuming that these three groups continue with their plans, this represents 16GWe of new nuclear generating capacity to 2025.

The Secretary of State for Energy and Climate Change, launched six new National Policy Statements (NPSs) in November 2009 to overcome planning delays for large energy proposals. In the nuclear NPS, the Government signed off 10 sites for new nuclear power alongside plans to reduce the planning timeframe. This means the nuclear sector could potentially account for 40 per cent of new energy provision by 2025 (around 40GW).[146] These sites will be used by the three consortia with public plans for nuclear capacity. The first new nuclear power stations are expected to come on-line in 2018 (see Figure 22).

[146] The Times, 9th November 2009 (see: http://www.timesonline.co.uk/tol/news/environment/article6909884.ece)

Figure 22: NIA Nuclear timeline (2008)



Source: NIA (2008)

The civil nuclear sector contributes £3.3bn to UK GDP and the combined civil and defence nuclear sectors generate £700m per year from overseas business. New nuclear power has the potential to generate significant value for UK companies. There were 2,300 companies involved in the development of Sizewell B and 90 per cent of the contractors were UK-based. Rolls Royce has estimated that the global civil nuclear market could be worth £50bn a year by 2023, up from its current £30bn a year.[147]

6.3 Potential barriers to the development of the nuclear industry

The main barriers to the development of the nuclear industry relate to supply chain shortages and the timing of Government intervention.

Nuclear power is currently undergoing a renaissance across the world and approximately 230 new nuclear plants are expected to be ordered by 2020. This includes 160GWe in China by 2030, 64GWe new nuclear capacity in the USA by 2030, and 20GWe in India.[148] This level of global demand could lead to shortages of at key points in the supply chain. The National Metals Technology Centre

[147] NAMTEC (2009) The supply chain for a UK nuclear new build programme
[148] NIA (2009) Opportunities for UK Companies in the nuclear supply chain presentation

(NAMTEC) suggests these shortages may include specialist pressure vessels, pipework and valves, and main Engineering, Procurement and Construction (EPC) contractor and plant management capacities. Large forgings are recognised as a global constraint in the nuclear sector and even if new production comes online from Sheffield Forgemasters, Japan Steel, and Doosan Heavy Industries, demand is still expected to exceed supply.

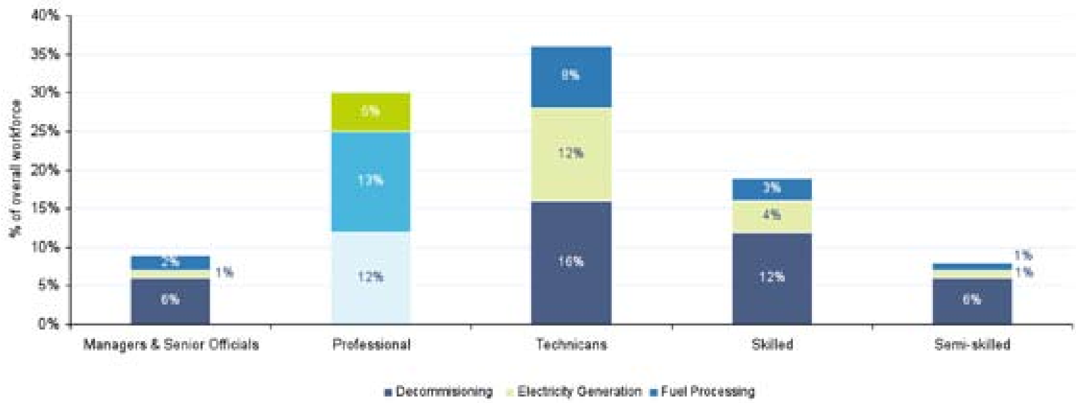
NAMTEC has also indicated that the timeliness of the Government's facilitative actions, especially the Generic Design Assessment (GDA) is vital to the proposed programmes, and this may be impacted by the shortage of skilled inspectors and engineers in the GDA process.[149]

6.4 Current employment in the nuclear industry

In 2009, nuclear operators directly employed 24,000 people in the UK: 12,000 in decommissioning; 7,400 in electricity generation; and 4,600 in fuel processing. A further 20,000 were indirectly employed in the nuclear supply chain, which includes activities such as construction and component manufacture.[150] Over half of this workforce is employed in the North West.

Figure 23 provides a breakdown of employment by occupation type. As the figure shows this sub-sector is dominated by professional and technical jobs, with less than a tenth of employment made up of semi skilled occupations. As Table 11 illustrates the types of jobs within these categories require a relatively high level of skill (i.e. generally NQF Level 3 or 4) again making the overall level of skill within the nuclear sub-sector above the UK average.

Figure 23: Proportion of civil nuclear workforce by occupation type



Source: Cogent (2009) Power People: The Civil Nuclear Industry 2009-2025

[149] NAMTEC (2009) The Supply Chain for a UK Nuclear New Build Programme
[150] Cogent (2008) Energy Skills: Opportunity and Challenge. A Response to the Energy White Paper

Table 11: Occupation and skill level within each occupational category

Occupational category	Occupation	NQF Level
Managers & Senior Officials	Directors of Production	5
	Technical Directors	
	Production/Maintenance Managers	
	Safety & Environment Managers	
	Support Services Managers	
Professional	Production/maintenance engineers	4
	Safety & Environment Scientist/Engineer	
	Support Services Scientist/Engineer	
Technician	Production & maintenance Supervisor	3
	Production & maintenance Technician	
	Support Services Technicians	
	Monitoring supervisor	
	Science Technician	
Skilled	Monitor	2
	Support Services Worker	
Semi Skilled	First Line Supervisor	1
	Operations Support Worker	
	Support Services Worker	

Source: PwC analysis of Cogent data (http://www.cogent-careers.com/roles/search)

The following vignette outlines the role of a Reactor Operator. Again this vignette will be revisited in chapter 9, to describe what this Reactor Operator might be doing in 2020.

Tell me a bit about your career to date.

1977 saw Star Wars hit the big screen and the Queen celebrate her silver jubilee. It also marked the beginning of my career within energy supply! It all started with a craft apprenticeship at Cliff Quay Power Station in Ipswich. And whilst I'm sad to say that Cliff Quay's no more, British Energy – and my career - has gone from strength to strength.
Over the years I've been involved in everything from providing technical support for experiments into atmospheric dispersion at nuclear power stations, through to working as part of the team which achieved a site licence for the Dounreay Prototype Fast Reactor. I've also worked as a Technical Trainer in Sizewell B's Operations Department.
I spent 5 years on shift operations as a technician, before moving into the control room as an Assistant Operations Engineer (AEO). Having gained substantial experience as an AEO, I was promptly promoted to Reactor Operator.

What does a Reactor Operator do?

I was recently seconded as a Simulator Tutor at Sizewell B. It's a role that's at the heart of the company's commitment to safety, and a large part of my time was spent testing and refining the simulators response to real plant data and test data. I also worked with new trainees, giving them the training, support and development they need to become fully-fledged Control Room Engineers.

What training have you received?

I've certainly had my fair share of career development. I've gained exposure to a wide variety of operations and job roles. More than that, British Energy supported me, personally and financially, during my BEng Honours degree in Mechanical Engineering.

Source:British Energy website, profile of a Reactor Operator, Sizewell B Power Station. (Available at: http://www.british-energy.com/pagetemplate.php?pid=302#3, last accessed 24th November 2009)

Due to the number of units coming off-line over the next decade, total employment is expected to decrease during this time. Cogent, the Sector Skills Council for nuclear, has outlined two scenarios: the first is that four new units (configured as two twinned units) are built by 2025 resulting in an overall direct employment of 16,200; in the second scenario eight new units are built by 2025 (configured as three twinned units and two single units) which is expected to result in a total direct employment of 18,600. The profile of these jobs is likely to change during this time, with a greater demand for decommissioning and a reduction in the demand for process operations, energy production and maintenance.[151] Either scenario would result in significant demand for construction jobs to implement the new build programme.

[151] Cogent (2009) Power People: The Civil Nuclear Industry 2009-2025

Cogent is reviewing its second scenario in light of the potential for new reactors to be built near Sellafield after a large site for a power plant was purchased by Iberdrola, GdF-Suez and Scottish

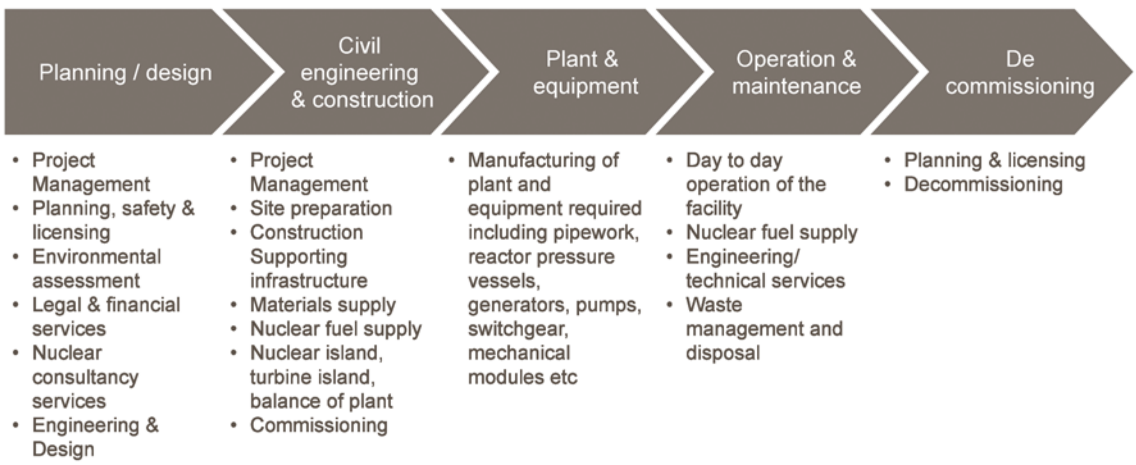
& Southern.[152] This could result in an additional 3.6 GWe, bringing the total potential nuclear capacity to 16GWe. If these sites do go ahead, the resulting direct employment is likely to take place from around 2012 onwards. Emerging projections from Cogent estimate a total workforce of around 130,000 person years, (comprised of 60 per cent construction, 20 per cent operations and 20 per cent manufacturing) and is expected to peak at circa 13,000 FTE in the latter part of the next decade.

A 2008 Nuclear Industry Association study concluded that the engineering, manufacture and construction skills required for a modest programme of nuclear new build could be resourced from within the UK supply chain.[153] At its peak, this is expected to involve an indirect workforce of around 20,000. Without new build, the industry will see a significant decline in total employment (direct and indirect) over the next decade.

6.5 The UK nuclear value chain

Figure 24 presents the nuclear value chain in the UK.

Figure 24: Nuclear value chain



Source: PwC analysis of stakeholder interviews

[152] World Nuclear News, 28th October 2009 (see: : http://www.world-nuclear-news.org/NN_New_nuclear_for_Sellafield_2810091.html)
[153] NIA (2008) The UK Capability to Deliver a New Nuclear Build Programme

Table 12 shows how the three broad categories of job function within the civil nuclear workforce map on to the nuclear value chain.

Table 12: Mapping job functions onto the nuclear value chain

Stage of value chain	Job function	Number of employees in 2009	% of sub-sector employment
Civil engineering & construction	Fuel processing	4,600	19%
Planning/design Plant & equipment Operation & maintenance	Electricity generation	7,400	31%
Decommissioning	Decommissioning	12,000	50%
	Total nuclear	**24,000**	**100%**

Source: PwC analysis of analysis of stakeholder interviews and Cogent (2009) Power People: The Civil Nuclear Industry 2009-2025

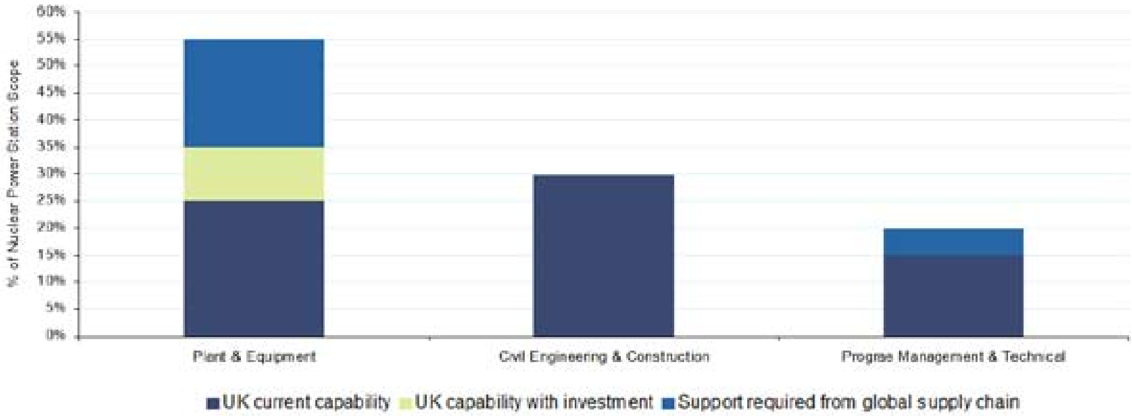
6.6 Current capability in the nuclear industry supply chain

The capability of the UK nuclear supply chain has been covered in several reports including the NAMTEC study in 2009, the NIA review in 2008, a report from IBM in 2005, and, as the Sector Skills Council covering nuclear energy generation, Cogent has researched the employment and skills implications of the proposed programme. The following paragraphs provide a brief summary of the key messages from these reports.

UK companies have been involved in the nuclear sector for a long time and they maintain a strong capability across the value chain, including construction, operation, fuel cycle facilities, decommissioning and waste management. The 2009 NAMTEC report states that:

> *"UK Industry has almost complete design, manufacture, construction and operational support capability for nuclear power and fuel facilities… British contractors, manufacturers and engineers have gained extensive experience from building, operation, maintenance and upgrading of nuclear plant and facilities in the UK and abroad".*

Figure 25: UK Nuclear supply chain capability



Source: NIA (2008)

There have been no new build nuclear projects in the UK for 15 years which has led to capability erosion in some key parts of the supply chain, but the UK maintains significant nuclear capability. According to NIA research, the UK has the potential to supply 70-80 per cent of the supply chain for the proposed nuclear programme. This view appears consistent with the IBM and NAMTEC reports, and expert interviews conducted during this research.

6.6.1 Planning and design

The NIA suggests that there are only a few UK companies with the capability to take on projects of this magnitude. The projects are therefore likely to be managed by a group of companies under the leadership of a large international firm, in similar fashion to project management on the 2012 Olympic Village project. With the exception of nuclear safety and licensing, the technical capabilities required are expected to be common to all large multi-disciplinary projects.[154]

The key value chain areas within this segment include programme management, quality management, financial services, legal services, contract management, cost estimators, quantity surveyors, nuclear specialists, infrastructure design. There are a large number of UK companies operating across these sectors with experience of large infrastructure projects.

6.6.2 Civil Engineering and construction

The Areva EPR and Westinghouse AP1000 plants currently being considered by nuclear developers have different implications for construction. The Westinghouse design adopts a modular construction process, which results in modules being manufactured in ports before being shipped to site for assembly. The NIA report indicates that UK companies have the capability and capacity to undertake

[154] NIA (2006)

all elements of the civil construction, including nuclear and turbine islands, balance of plant and the supporting infrastructure. The majority of the construction in the new build nuclear programme requires conventional construction capability and skills, and specialist nuclear construction expertise is available through those currently engaged in construction in the UK decommissioning programme.

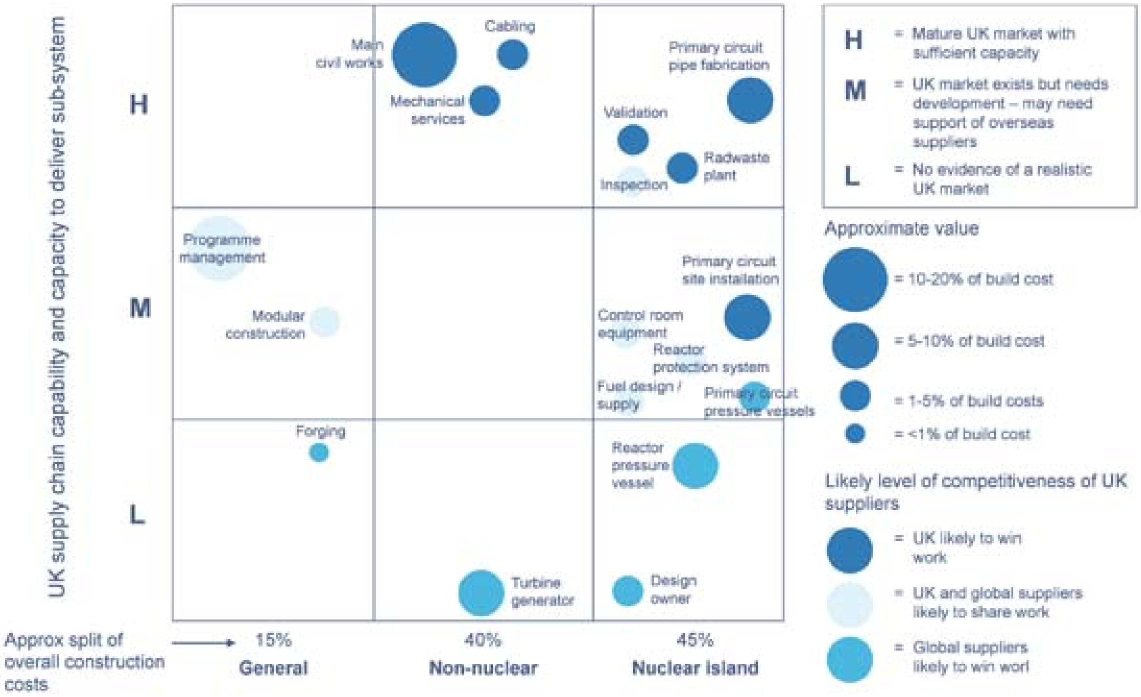
The NIA suggests that the nuclear projects would use a minimal amount of the total UK capability in construction and building products. Its analysis indicates that nuclear new build equates to 0.5 per cent of UK construction output, and although this is based on a smaller nuclear programme, it is unlikely that this will represent a large share of construction output.

6.6.3 Plant and equipment

In a new build nuclear project, plant is either specialist (reactor and turbine) or conventional (pipe work and boilers). The nature of the Generic Design Assessment means there is minimal scope for UK companies to be involved in the component design, unless they were already specified early in the design process. As noted above, design selection impacts on potential employment in manufacturing as the Westinghouse modular design is focused on off-site assembly.

The NIA suggests that, while the UK has lost some of its manufacturing capability in some areas such as large turbines and generators, many UK companies have significant manufacturing expertise. Some UK companies are already considered to be market leaders in the global nuclear market, especially in main coolant pumps, high quality forgings, specialist inspection equipment and assemblies. As a result, the UK has existing capability to manufacture approximately 50 per cent of the required plant and equipment, with the potential for 70 per cent if companies made the necessary investment. Ultimately the UK does not have the capability to manufacture 100 per cent of the necessary equipment, instead relying on the global supply chain for components like large head forgings and steam generators.

Figure 26: IBM Summary of UK supply chain capability and capacity



Source: IBM (2006)

Furthermore, whilst the UK has strong capabilities across the value chain, this does not necessarily mean that businesses here will gain new work as the nuclear industry is internationally competitive.

6.6.4 Operation and maintenance

The UK has extensive experience of operating civil nuclear reactors from its existing fleet. Employment and skills capability relating to operation and maintenance is covered in more depth above in the "Current employment in the nuclear industry" section.

6.6.5 Decommissioning

UK companies have experience in the nuclear decommissioning sector from both large UK decommissioning projects and from overseas projects. Employment and skills capability relating to decommissioning is covered in more depth above in the "Current employment in the nuclear industry" section.

6.7 The potential for UK involvement in the new build programme

The Office of Nuclear Development (OND) was launched in June 2008, to bring together the Government's resources to facilitate investment across the UK nuclear value chain.

In contrast to previous UK nuclear projects which have involved the construction of unique nuclear reactors which have limited export capability, the new generation of reactors will use adopt generic nuclear reactor designs from overseas vendors. However, this strategy is still expected to lead to significant value being generated in the UK from planning, construction, operation, maintenance, waste management and decommissioning.

The manufacturers of the two nuclear plant designs being considered in the UK already have agreements with several UK companies. Westinghouse has arrangements with Rolls Royce, BAE, Doosan Babcock and Sheffield Forgemasters, while Areva has deals with E.ON, Rolls Royce, Balfour Beatty and Vinci. These two manufacturers have also publically stated that the UK supply chain will be very involved in the proposed new build programmes:

> *"Areva maximises the use of both its globally integrated manufacturing capability and local resources in all its new build projects, Areva looks forward to working closely with the UK supply chain to develop the appropriate strategy for the UK." Areva*

> *"Our approach of "we buy where we build" is based on a track record of localisation in countries like Korea, and we fully expect to repeat the process in the UK. We have been most encouraged by the enthusiasm of UK suppliers to engage with us, and we are sure that the reactant coolant casings currently being made in the UK for the Chinese AP1000 plants will be the first of many contributions to the AP1000 fleet to be produced here." Westinghouse*

These vendors have clearly outlined their requirements for equipment in their plant designs and their procurement policies in the design assessment phase of the planning process. This has enabled UK businesses to better assess how much of the supply chain they can deliver, while the Energy and Planning Bills have clarified the approval timescales, and thus given UK businesses more confidence when making investment and resource decisions. Ultimately the extent of businesses' involvement in the nuclear value chain is dependant on their willingness to invest in nuclear skills, services and manufacturing capability.

Another consideration is that the design selection (Areva vs. Westinghouse) is likely to impact the involvement of UK companies in the supply chain.[155] But experts suggest the Government sees benefits in diversity, and different sites suit different technologies, so both designs are likely to be adopted in different locations.

[155] NAMTEC (2009) The Supply Chain for a UK Nuclear New Build Programme

The NIA has stated that approximately 80 per cent of the nuclear new build programme is similar to other major construction projects rather than being nuclear specific.[156] Capacity in the construction sector is not expected to be a constraint as the proposed projects represent less than 5 per cent of current construction resources. As noted previously, the NIA report on the UK nuclear capability also suggests the UK could potentially supply between 70-80 per cent of a new build programme.

It is widely acknowledged that the UK cannot supply 100 per cent of the supply chain, as some of the key components including reactor pressure vessels, large forgings, generators cannot be manufactured by UK businesses, and there are only a handful of companies in the world with this capability.

As part of the Low Carbon Industrial Strategy, the UK is establishing a Nuclear Advanced Manufacturing Research Centre, which will be supported by Government funding of up to £15m. This Centre will be based on a consortium of approximately 30 companies from the UK nuclear supply chain (led by Rolls Royce) which will work together with universities to develop processes for manufacturing nuclear components and assemblies, and develop management processes, training, and workforce development programmes to achieve civil nuclear standards and accreditation.[157] Indeed, Rolls Royce states that it has 2,000 employees and 260 suppliers accredited to nuclear standards at the current time.[158]

6.8 Export potential for UK nuclear businesses

If UK companies develop relevant nuclear capabilities now, there is potential for significant export growth as nuclear deployment rises. Historically, reactors constructed for the UK market have been unique, which has limited the export potential for UK businesses. However, the new generation of reactors is based on a generic design, which significantly increases the export potential.

> *"Once UK companies have reached the necessary quality specifications and are involved in the nuclear supply chain, there may be more potential for exports. There are examples of countries, like the UAE, who will want nuclear projects built quickly and will be less interested in the value chain." Stakeholder interview*

> *"The UK is an early mover into this generation of nuclear technology which means there may be export potential for those companies involved in the supply chain once they have been through the long approval process and have demonstrated their nuclear credentials in practice."*
> *Research Director, Cogent*

[156] NIA (2008) The UK capability to deliver a new nuclear build programme
[157] BIS website, (see: http://interactive.bis.gov.uk/advancedmanufacturing/annex-case-studies/research-centres/), last accessed 1st December 2009
[158] Rolls Royce website, 15th July 2009 (see: http://www.rolls-royce.com/nuclear/news/2009/150709_uk_nuclear_research_centre.jsp)

Table 13 presents the Aveva view of the opportunities available to UK businesses across a range of services.

Table 13: Areva view of opportunities for UK businesses

Service	UK Opportunity	Export Opportunity	Investment Needed
Detailed understanding and development of Nuclear Safety case	✓	Some	No
Consultancy: technical and commercial feasibility studies and evaluation	✓	✓	No
Manufacturing and specialist equipment supply	✓	✓	Most likely
Construction, installation and commissioning	✓	✓	Not necessarily
Post-build operational support	✓	Within Europe	Yes, in skills & training
Integrated fuel and waste management/services	✓	✓	Possibly

Source: NAMTEC (2009)

6.9 Current skills needs for the nuclear industry

Cogent, the Sector Skills Council which covers the nuclear industry, has identified a 33 per cent deficit of people qualified at NQF Levels 2 and 3 and a 12 per cent surplus of people qualified at NQF Level 1 and below.[159]

The biggest employment challenge facing the industry over the next decade will be replacing the large numbers of highly skilled and very experienced individuals who are due to retire during this time. Cogent estimates that up to 70 per cent of the current workforce will have retired by 2025, creating a general skills gap of up to 14,000 workers.[160] As decommissioning activity is expected to increase during this time, recruitment and retention in this field becomes increasingly important. In order to address this potential skills gap the industry the industry will need to recruit around 1,000 new graduates or apprentices per annum to perform operations roles. Skills in safety and security are evidently crucial to the nuclear industry:

> *"A significant proportion – at least 60 per cent - of the new jobs in the new build programme will be in construction. Many of these will be at skill level 3. Many people in the sector will never have worked on a nuclear licensed site before, nor will they have worked to the ultra high standards of precision, quality, safety and security. With this in mind there is a pressing need for accredited training of the workforces and in nuclear awareness on site."*
> *Research Director, Cogent*

There is also potential to re-skill employees within the fuel processing, power generation and decommissioning phases of the nuclear cycle in order to improve retention:

> *"Regional economies will be repositories of skilled and nuclear literate labour with potential for re-skilling to facilitate retention and transition between the various phases."* [161]

6.10 Current provision of skills for the nuclear industry

There are a number of nuclear specific training courses provided by National Skills Academy for Nuclear Quality Assured Providers, ranging from NQF Level 2 to Level 4. These are set out in Table 14.

[159] Cogent (2008) Nuclear Industry Factsheet
[160] Cogent (2009) Power People: The Civil Nuclear Industry 2009-2025
[161] Cogent (2009) Power People: The Civil Nuclear Industry 2009-2025, p.22

Table 14: Nuclear training courses

Course	Description	Qualification	Provider
Award for Nuclear Industry Awareness	Designed with industry involvement to provide people who are embarking on a career in the nuclear sector with as foundation level of understanding of the industry and its specific requirements		
Community Apprenticeship	Funded by the NDA (Nuclear Decommissioning Authority) this scheme enables supply chain companies to take advantage of additional funding to take on Apprentices for the first time or grow additional Apprentice skills for their business, enabling continued and better resource capability to support the Nuclear Site Licence companies to achieve their delivery objectives safely to time and cost.	Apprenticeship	GEN II, Training 2000 & TTE Ltd - (Northwest/ Northeast)
Nuclear Decommissioning		Foundation Degree	Lakes College in partnership with GEN II (Northwest/ Northwest) & Bridgwater College (Southwest)
HVAC Energy Engineering / Foundation degree in Construction and Civil Engineering		Foundation Degree)	UCLAN - Northwest/ Northeast
Nuclear Related Technology (Commissioning & Maintenance)	Developed with the intention of attracting students seeking to commence a career in technology or engineering who can apply their education in a nuclear setting.	Foundation Degree	Delivered by GEN II - Validated by UCLAN
Nuclear Related Technology (Instrumentation & Control)		Foundation Degree	Delivered by GEN II - Validated by UCLAN

Course	Description	Qualification	Provider
Nuclear Related Technology (Science & Process)	Developed with the intention of attracting students seeking to commence a career in technology or engineering who can apply their education in a nuclear setting.	Foundation Degree	Delivered by GEN II - Validated by UCLAN
Nuclear Decommissioning		NVQ Level 2	Bridgwater College (Southwest), GEN II (Northwest/ Northeast)
Radiation Protection		NVQ Level 2	Bridgwater College (Southwest)
Nuclear Decommissioning		NVQ Level 3	Bridgwater College (Southwest), GEN II (Northwest/ Northeast)
Radiation Protection		NVQ Level 3	Bridgwater College (Southwest)
Science and Engineering Ambassadors Programme	For all Nuclear employees with an interest in STEM to become Science and Engineering Ambassadors and promote both the uptake of STEM subjects in schools and the Nuclear Industry as an excellent career path.		

Source: The National Skills Academy Nuclear (http://www.nuclear.nsacademy.co.uk/products-and-services)

7 Industry insight: microgeneration

Microgeneration Summary

Microgeneration is the generation of low and zero carbon heat and electricity on-site (at the point of demand). The key microgeneration sub-sectors considered in this report are solar thermal, solar photovoltaic, small scale wind, Ground Source Heat Pumps (GSHP), Air Source Heat Pumps (ASHP) biomass, Combined Heat and Power (CHP), micro hydro and fuel cells.

In the absence of a comprehensive data source covering direct employment in microgeneration technologies we have estimated total employment in 2009 to be 1,000. This is based on the slow growth in design, manufacturing, installation and maintenance jobs linked to these technologies within the UK. Our desk-based research and stakeholder interviews suggest that system design, installation and maintenance activities are currently undertaken by employees within the building services engineering sector (i.e. electrical trades and installation, plumbing, heating and ventilation and air conditioning and refrigeration).

Few additional jobs appear to have been created by design, installation and maintenance of microgeneration technologies to date. Evidence suggests this is because, on average, installers have generally only undertaken a handful of installations each. In the case of discretionary technologies, which are installed in addition to traditional technologies (e.g. gas boilers), additional jobs may be created in the future because these technologies are not displacing existing systems and also because many forecasts suggest households may have multiple microgeneration systems installed.

Essential microgeneration technologies, on the other hand, are installed as an alternative to traditional technologies and are unlikely to create significant new employment opportunities in the UK. However, the demand for the design, installation and maintenance of microgeneration systems is beginning to change the types of activities undertaken by employees within the building services engineering sector. Research conducted by SummitSkills in 2008[162], found that the involvement of UK building services engineering companies in microgeneration technologies varied greatly depending on the type of technology (i.e. from 2 per cent involved in micro hydro and fuel cells to 29 per cent involved in CHP). This research also identified significant regional variation in terms of the prevalent type of renewables technology, but with no apparent rationale for this selection.

Around one in ten UK building services engineering companies has employed migrant labour within the last three years. This has the potential to result in staff shortages (and therefore create skills gaps and shortages) for the sector going forward as many migrant workers may choose to return to their country of origin or because of the recession may move on to other countries which are able to offer more attractive employment packages.[163]

[162] SummitSkills (2008) Report on additional research into specific themes arising from the Sector Skills Agreement for building services engineering
[163] SummitSkills (2008) Report on additional research into specific themes arising from the Sector Skills Agreement for building services engineering

Whilst the design, installation and maintenance of microgeneration systems does not require very different skills than those which already exist within building services engineering sector. It will require some additional underpinning knowledge, in terms of system design, integration with other technologies and for some technologies – health and safety. Qualified trades persons could acquire this knowledge relatively easily via a short training course. Historically, manufacturers have been the primary providers of training courses and they have been specific to their technologies.

Training provision for microgeneration technologies is low. There are currently no identified skills gaps in this area due to the relatively low levels of demand for microgeneration installations to date. However, weaknesses in management and leadership, business acumen and entrepreneurship skills have been identified within the building services engineering sector in general, which could create productivity issues for microgeneration in the future.

To some extent demand for technical training needs to be stimulated by the sector, however, if providers are not proactive in developing and increasing the supply of training courses they may be unable to meet a sudden increase in demand due to the increased uptake in microgeneration technologies. This may create a skills gap, which will have negative implications for the quality and scale of the UK's microgeneration activities.

7.1 Introduction

Microgeneration is the generation of low and zero carbon heat and electricity on-site (at the point of demand)[164] In the UK, energy is primarily generated centrally and considering that the average thermal efficiency of a coal power station in the UK is 36 per cent (or 49 per cent in a combined-cycle gas turbine), once its transmission and distribution losses are considered, this system delivers approximately one third of the primary energy input to users.[165]

The key microgeneration sub-sectors considered in this report are solar thermal, solar photovoltaic, small scale wind, Ground Source Heat Pumps (GSHP), Air Source Heat Pumps (ASHP) biomass, Combined Heat and Power (CHP), micro hydro and fuel cells. Other related technologies considered within this analysis include district heating and smart meters.

[164] UKERC (2009) Power to People
[165] Energy Savings Trust (2007) Generating the Futuret

Table 27 presents a brief description of the main microgeneration technologies that are currently available.

Table 27: Microgeneration technologies

Technology	Description
Solar thermal	Solar thermal systems use roof mounted solar collectors in conjunction with a heat exchanger in the hot water tank to heat water. The use of solar collectors for space heating is limited because demand for space heating coincides with the lowest solar input, whereas demand for water is much flatter.[166]
Solar PV	Solar PV is considered to be a mature technology because high volumes of PV are installed worldwide. The technology converts the suns energy into electrical energy using thin layers of semiconductor materials.
Small-scale wind	Small-scale wind systems operate in the same way as larger wind turbines. As discussed earlier in the report, the UK has a strong wind resource, but small scale wind is a relatively new entrant into the market and uptake may restricted by poor performance turbines in urban locations.
Biomass	Biomass systems use biological material (including wood pellets and energy crops) to generate heat and electricity. The sun's energy is captured and stored during the photosynthesis process, which is then converted to heat and/or electricity during the combustion process. Biomass can either be used in an individual dwelling or as part of a community (district) heating scheme.
Ground Source Heat Pumps (GSHPs)	Ground Source Heat Pumps (GSHPs) use heat collecting pipes containing water buried about 1.5m metres below the ground to extract stored energy in the ground for space and water heating. Since they require electricity to operate, GSHPs are considered to 'amplify the heating effect of electricity'.
Air Source Heat Pumps (ASHPs)	Air Source Heat Pumps (ASHPs) use a vapour compression cycle to pump heat from ambient air into a buildings heating system and are primarily used for space heating.[167]
Micro-hydro	Micro-hydro systems are placed next to a river or a stream and generate electricity by converting the kinetic or potential energy in the water into electricity with a small turbine. Deployment in the UK is limited by access to streams and rivers.
Fuel Cells	Fuel Cells convert the chemical energy in hydrogen, methane (natural gas) and propane directly into electricity by generating a reaction between the fuel and an oxidant. Fuel cells have the potential to be significantly more efficient at producing electricity than traditional power generating techniques as their performance limits are not limited by laws of thermodynamics.[168]
Combined Heat and Power (CHP)	Combined Heat and Power (CHP) systems use a variety of fuels including gas, biomass and fuel cells to generate electricity, whilst capturing the heat generated during the combustion process. The power generation unit can be either a stirling engine, reciprocating engine or a fuel cell, each of which has different heat and power efficiencies. In the longer term, fuel cell CHP systems offer the most potential, but this technology requires further development.[169]
District Heating (Community heating)	Involves the replacement of individual heating systems with a local central heating plant (usually a CHP system). The hot water generated is distributed to buildings in the proximity with a network of heavily insulated pipes. The heat and electricity generated can be used for a mixture of residential and other buildings (shops, schools, hospitals etc)

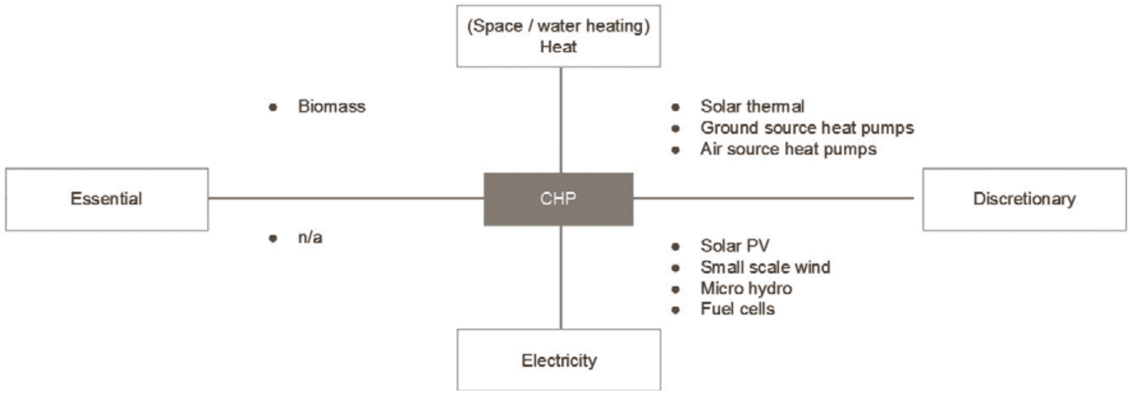
Source: PwC analysis of stakeholder interviews

[166] BERR (2008) Microgeneration strategy: Progress Report
[167] NERA (2009) The UK Supply Curve for Renewable Heat
[168] NHBC (2008) A review of microgeneration and renewable energy technologies
[169] University of Oxford (2005) 40 per cent House

Another consideration with microgeneration is smart meters. These devices are used to monitor household energy usage and within the microgeneration context, they can also measure the balance of energy exported back to the grid from the household microgeneration unit so as to calculate energy bills/revenue.

Microgeneration technologies can be divided into discretionary and essential solutions, and into heat or electricity generators (or both in the case of Combined Heat and Power (CHP), as shown in Figure 28.

Figure 28: Microgeneration technologies



Source: PwC analysis of stakeholder interviews
Note: District Heating has not been considered on here because the decision process for switching to from a conventional heating system to district heating is different and requires a collective decision (unlikely to be made by one individual)

Element energy suggests householders differentiate between systems which complement the existing energy system in the house (discretionary) and those which are an integral part of the energy system (essential). In essence, every house requires a heating system, so biomass and CHP systems are considered to be alternatives to traditional fossil fuel boilers when the traditional unit is due for replacement. In contrast, if a solar PV system is selected, the household still requires a space and water heating unit, so it is a discretionary choice.

The distinction between discretionary and essential microgeneration systems is an important consideration for employment in the sector. Since essential systems are effectively a replacement for a conventional energy unit, there is a substitution effect in terms of employment because installers of conventional technologies are likely to simply install microgeneration instead. In contrast, discretionary systems have the potential to create additional employment because it is not displacing an existing household technology.

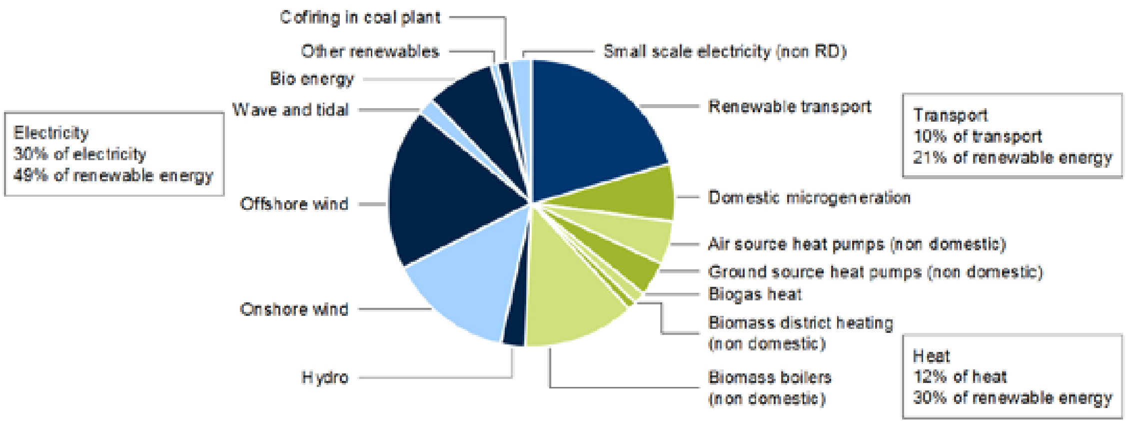
There are a wide range of different possibilities, but one example is that a consumer could have a conventional gas boiler for space and water heating, but then a solar PV system for generating electricity. The net impact of this situation is that the house has two systems installed, compared to just one if they had just the conventional energy unit, which creates additional man days per installation. In contrast, a consumer could have a Ground Source Heat Pump for space heating, a solar thermal unit for water heating, and a solar PV unit for generating electricity. The net impact of this second situation is that the house has three systems installed, creating further man days of installation effort for each installation.

A fundamental difference between low carbon heat and low carbon electrical energy is that low carbon electricity can be generated at a national or local level, whereas heat needs to be generated close to its point of use as it cannot be distributed over long distances without significant loss.[170] The current centralised system of electricity generation creates significant quantities of 'waste' heat, whereas generation at a local level allows users to capture the heat energy for water and space heating.

Heat energy represents a significant proportion of energy consumed in the average house and because heat energy needs to be produced locally, there is significant potential for heat producing microgeneration systems.

Renewable sources currently accounts for 0.6 per cent of total heat demand, although in the scenario presented in the Government's Renewable Energy Strategy, it is expected to increase to 12 per cent in 2020. This forecast also suggests the focus for heat will be on non-domestic applications, which is an important distinction because it implies that the focus will be on installing low carbon heat systems in schools, retail centres, hospitals etc.

Figure 29: Illustrative mix of technologies in lead scenario 2020 (TWh)



Source: HMG UK Renewable Energy Strategy (2009)

[170] BERR website, (see: http://www.berr.gov.uk/files/file39567.pdf), last accessed 1st December 2009

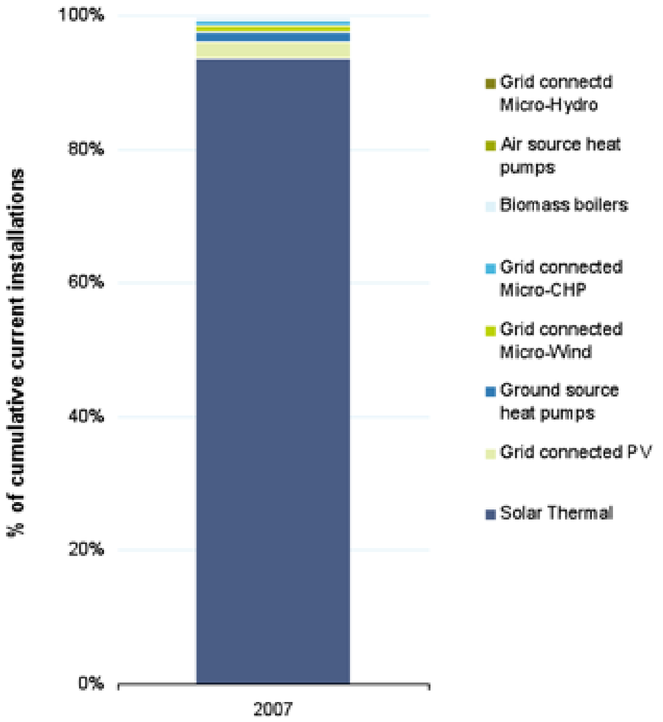
In this scenario small scale electricity represents a minimal share of energy generation, but it is expected to play an important role in the UK in the future.

7.2 Current state of the industry

Element Energy (a low carbon consultancy firm) suggests there is currently between 95,000 and 98,000 microgeneration units installed in the UK at the end of 2007, up from 82,000 in 2004, representing an estimated 16MW of grid connected electricity generating capacity installed.[171] The focus in the UK is currently on heat generating technology, with 90,000 heat only systems installed (mostly solar thermal), compared to around 5,000 grid-connected electricity devices (mostly solar PV).

The most popular microgeneration technology is solar thermal with an estimated 90,000 cumulative installations and between 5,000 and 6,000 units per year currently being installed as shown in Figure 30. This growth has been driven by the low relative cost compared to other technologies like solar photovoltaic, although it is still characterised by long payback periods.

Figure 30: Cumulative installed microgeneration systems (2007)



Source: Element Energy (2008)

[171] Element Energy (2008) The Growth Potential for Microgeneration in England, Wales and Scotland

Microgeneration is currently relatively expensive when compared to conventional energy solutions and currently there is no microgeneration technology with a superior economic case (with the exception of some niche locations). Furthermore, research by Element Energy indicates that consumers place a low value on ongoing energy costs compared to up-front capital costs, which is problematic since microgeneration is typified by high up- front costs and low on-going costs.[172]

This paradox makes microgeneration demand highly dependant on Government support. A report by the Energy Savings Trust suggests current demand for heat microgeneration technology is confined to a niche market of environmentally concerned, older, middle class householders, and that one fifth of these people have a job or hobby related to the environment.[173] In other countries with higher microgeneration deployment levels, rollout has been achieved with loans and subsidised output.

The Government launched its Microgeneration Strategy in March 2006 to establish the conditions for microgeneration to become a viable source of energy generation. This has resulted in a simplified planning process, the rollout of export tariffs for electricity exported back to the grid, the removal of technical barriers, increased consumer awareness and the launch of the Microgeneration Certification Scheme, which provides consumers with independent certification of microgeneration products, services and installers.

Growth in the microgeneration sector to date has been primary driven by two Government initiatives:

- The Low Carbon Buildings Programme; and
- The Zero Carbon Homes initiative (under the Code for Sustainable Homes). [174]

The Low Carbon Buildings Programme (LCBP) was launched in April 2006 as the primary support mechanism for microgeneration. The programme provided grants of between £1,000 and £2,000 per kwh, or up to 30 per cent of the costs, with the level of support differing by technology type. However, the level of support available under the scheme declined in the second year of the LCBP (i.e. from a maximum of £15,000 to £2,500 in solar PV), which led to a 22 per cent decline in the number of applications across all technologies.[175] The UK Renewable Energy Centre has stated that the LCBP scheme was limited by the size of the funding pot and the lack of clarity surrounding its continuation, and that the funding cut meant microgeneration costs for some technologies were raised above consumers willingness to pay.[176]

The Code for Sustainable Homes was introduced in 2006 and from May 2008 it became mandatory to assess the sustainability of new homes. The Code aims to improve carbon efficiency new houses by 25 per cent against 2006 levels in 2010, by 44 per cent in 2013, and for new homes to be zero

[172] Element Energy (2008) The Growth Potential for Microgeneration in England, Wales and Scotland
[173] Energy Savings Trust (2008) Yes in My Back Yard
[174] In July 2007 the Government's Building A Greener Future: Policy Statement announced that all new homes will be zero carbon from 2016.
[175] UKERC (2009) Power to the People
[176] UKERC (2009) Power to the People

carbon by 2016. This is key driver of current microgeneration demand, but a lack of clarity about how much of the energy needs to be generated on-site as opposed sourcing low carbon energy from central sources (offshore wind farms etc) is constraining demand.[177]

The microgeneration sector has grown relatively slowly and in recent months retailers (including Currys and B&Q) who were quick to offer renewable energy products to consumers in 2006 are now reported to be removing the products from their shelves.[178] Furthermore, the current economic climate has resulted in reduced demand for microgeneration technology:

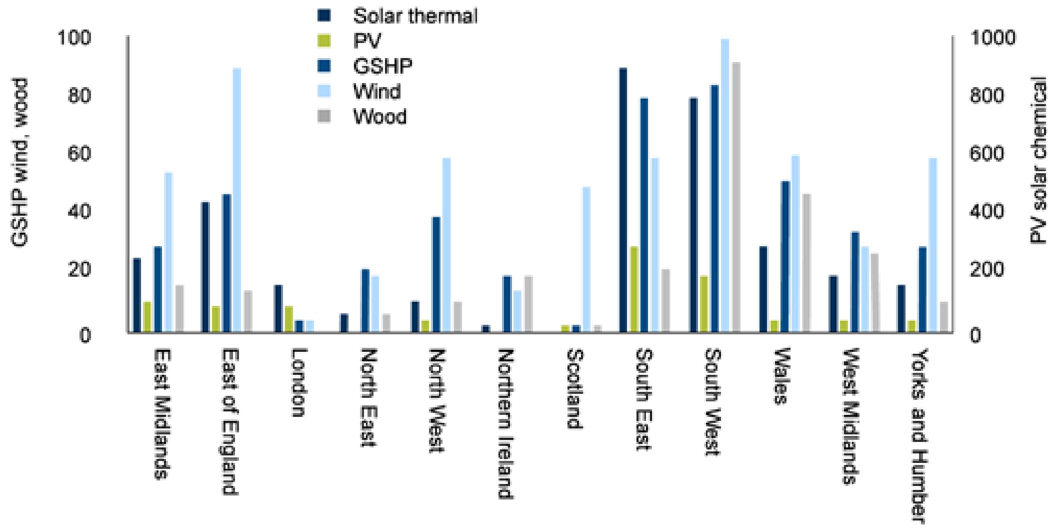
> *"Installations have decreased a lot recently because microgeneration technology is expensive and has long payback periods, so consumers just don't have the finance for it at the moment…. one installer I spoke to recently said he had not installed a solar panel for 18 months" (SummitSkills Interview)*

While Microgeneration systems have significant potential, the UK Energy Research Centre suggests growth is currently constrained by high up-front costs, long payback times, low capacity of supply chains and skilled installers, planning and regulatory issues, and social and cultural barriers.[178]

7.2.1 Regional variations in microgeneration deployment

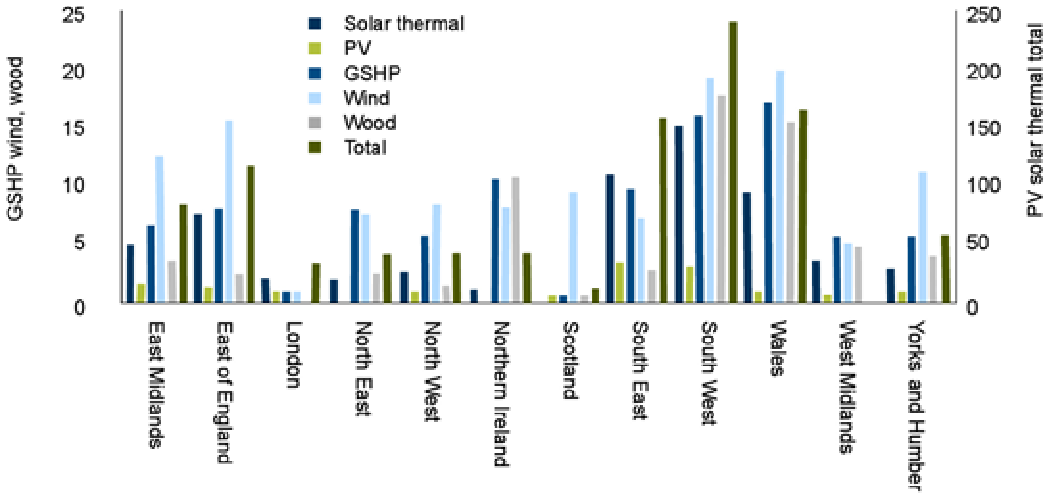
The 2009 UKERC report suggests the highest uptake of microgeneration under the LCBP programme was in the South West, with nearly 250 installations per million people.[180] London had relatively low uptake for all technologies except solar installations (which is possibly a result of barriers to installation in an urban environment). Scotland has the lowest uptake under the LCBP programme, but this may be a result of other support policies driving growth in Scotland. Figure 31 illustrates the level of installations per region.

Figure 31: Total number of microgeneration installations by region and technology



[177] Institute of Environmental Management & Assessment (2009) Zero carbon homes: house builders give their perspective
[178] The Guardian website, 2nd February 2009, (see: http://www.guardian.co.uk/environment/ethicallivingblog/2009/feb/02/energy-carbonemissions)
[179] UKERC (2009) Power to the People
[180] UKERC (2009) Power to the People

Figure 32: Number of microgeneration installations per 1 million people by region and technology



Source: UKERC (2009)
Note: This data shows only installations under the LCBP, but this is likely to represent the majority of total installations because the various microgeneration technologies currently on the market are largely dependant on support mechanism like LCBP.

This is supported by research carried out by SummitSkills which identified significant regional variation in terms of the types of renewables technology with which installers were involved. [181]

The UK Energy Research Centre suggest the regional variations can be explained by geographic, demographic and income variations, as well as regional policies. [182]

Another consideration is that different microgeneration systems are suited to different locations. Studies have indicated that small scale wind turbines in urban locations can in some cases not even provide sufficient electricity for their own electronics.[183] Ground source heat pumps can also be unsuited to urban locations because they require sufficient area for the collector and site access for bore hole machinery. Wood-fuelled boilers are best sited close to supplies of biomass as they require storage space and there can be issues related to air quality in urban locations, but overall biomass is not limited to rural areas.

[181] SummitSkills (2008) Report on additional research into specific themes arising from the Sector Skills Agreement for building services engineering
[182] UKERC (2009) Power to the People
[183] The Guardian website, 13th January 2009, (see: http://www.guardian.co.uk/technology/2009/jan/13/wind-turbine-efficiency-postlethwaite-cameron)

7.3 Potential growth in the microgeneration sector

The Zero Carbon Homes (ZCH) initiative discussed earlier is expected to drive significant growth in microgeneration deployment closer to 2016 as the UK nears its zero carbon target deadline and once there is more clarity about the exact share of energy which needs to be generated on-site.

The Government has also announced plans to launch a Feed in Tariff (FIT) in the UK in April 2010. This is essentially a long-term contract with electricity providers to buy renewable energy at a certain price. The Feed in Tariff simplifies the process of supporting small scale renewables and has proven to be very effective in other countries such as Germany, where deployment of solar PV increased almost threefold following the launch of the tariff in 2004. The UK Government is also in the process of developing the Renewable Heat Incentive (RHI) to support heat microgeneration technologies, which is expected to be introduced in April 2011. These two measures have the potential to radically change the microgeneration landscape because they fundamentally change the economics of investing in microgeneration systems. Deployment will depend on consumer response to the tariffs, but stakeholder interviews suggested this has the potential to trigger rapid growth in the number of installations in the UK.

Smart meters are currently an area of significant interest globally and they have the potential to impact future microgeneration growth. This technology will measure in real time the quantity of power being fed into the grid so that a large number of energy generation sources could be accommodated. Ofgem currently has plans to create four “smart grid cities” with £500m set aside from customers’ utilities bills.[184] This move will help to create the necessary infrastructure for microgeneration deployments as Feed in Tariffs come into effect next year. Much like other aspects of microgeneration there is a great deal of uncertainty related to smart meters, and stakeholders interviewed in this study had mixed views about the timescale for rollout and level of deployment. In the best case, if smart meters were to be rolled out across the UK (across c.26m households and non-domestic buildings), the installation process would require a large number of qualified installers.

In the longer term, there is certainly significant potential for low carbon primary heating systems. This is particularly the case given that typical heating systems have a lifespan of between 15 and 20 years and that the number of new homes in the UK is expected to increase considerably. There is, therefore, an opportunity to establish low carbon systems as a standard option for consumers during the replacement and new build cycle.

The outlook for district heating is unclear, but the significant complexity and costs of installing these systems retrospectively is likely to constrain demand and limit deployment primarily to new builds.

Forecasts for microgeneration differ significantly between sources as the future impact of various drivers like Zero Carbon Homes and the forthcoming Feed in Tariffs and Renewable Heat Incentives are unclear. Table 15 illustrates a range of the forecasts for deployment in 2020.

[184] The Guardian website, 3rd August 2009, (see: http://www.guardian.co.uk/business/2009/aug/03/ofgem-smart-grid-cities)

Table 15: Estimates for microgeneration deployment in 2020

Forecast	Estimated microgeneration stock in 2020	Dominant microgeneration technologies
Element Energy **(June 2008)**	(Annual installations over 480k per annum from 2016)	Differs between scenarios, but fuel cell CHP, solar PV, ASHP, and stirling CHP generally have significant deployment
Renewables Advisory Board (RAB) **(November 2007)**	(Annual installations over 480k per annum from 2016)	Solar PV, medium biomass CHP and low H:P Micro CHP
Energy Savings Trust **(November 2007)**	c.2m – 10.6m	Differs between scenarios, but stirling engine CHP, 1KWe fuel cells, solar thermal and wind generally have significant deployment and solar PV is almost non-existent

Source: PwC analysis of Element Energy (2008), The growth potential for Microgeneration in England, Wales and Scotland, RAB (2007), The role of onsite energy generation in delivering zero carbon homes and Energy Savings Trust (2007), Generating the future.

These estimates of cumulative installations to 2020 vary considerably depending on possible Government initiatives (including Feed in Tariffs, Renewable Heat Incentives, requirements to fit specific technologies for new builds or when replacing conventional technologies). The uncertainty surrounding the future importance of different technologies and future microgeneration stocks make forecasting employment levels and skills requirements challenging, however, possible implications for the sub-sector are discussed in the Scenarios section of this report.

7.4 Current employment in the industry

There is limited data available on employment in the microgeneration sector. Our desk-based research and stakeholder interviews indicate that there is approximately 1,000 employees within the sector and that this employment is currently focused in the installation sector and to a lesser extent in the manufacturing sector (in small scale wind, solar and biomass) and in maintenance due to the present scale of deployment. The inherent nature of this sub-sector makes assessing the scale of the low carbon workforce difficult as many of the skills required for design, installation and maintenance are common to standard occupations within the building services engineering sector, which currently employs around 345,000.

Our analysis of the current literature and our discussions with stakeholders suggest there are few individuals or companies devoted exclusively to microgeneration installation, Rather this activity is currently undertaken by existing trades within the building services engineering sector, such as domestic plumbers and electricians, to expand their offering to include the installation of microgeneration equipment, such as solar panels.

In 2006, BRE estimated that there were approximately 400 individuals involved in installation in the microgeneration sector.[185] This number is broadly consistent with research from the UK Energy Research Centre which suggested there were in the region of 370 companies involved in installation under the Low Carbon Buildings Programme (LCBP) and the number of installers who are part of the Microgeneration Certification Scheme (i.e. around 400). Given that this report indicates that the majority of these companies handled only a few installations, microgeneration activities are unlikely to account for a large proportion of their overall work.

Migrant workers play a significant role in the UK building services engineering sector with approximately one company in ten employing migrant labour within the last three years – although this is much more prevalent within large companies than SMEs. There were also some regional variations in the deployment of non-UK nationals, with London and the East of England employing the highest percentage of migrant workers.[186]

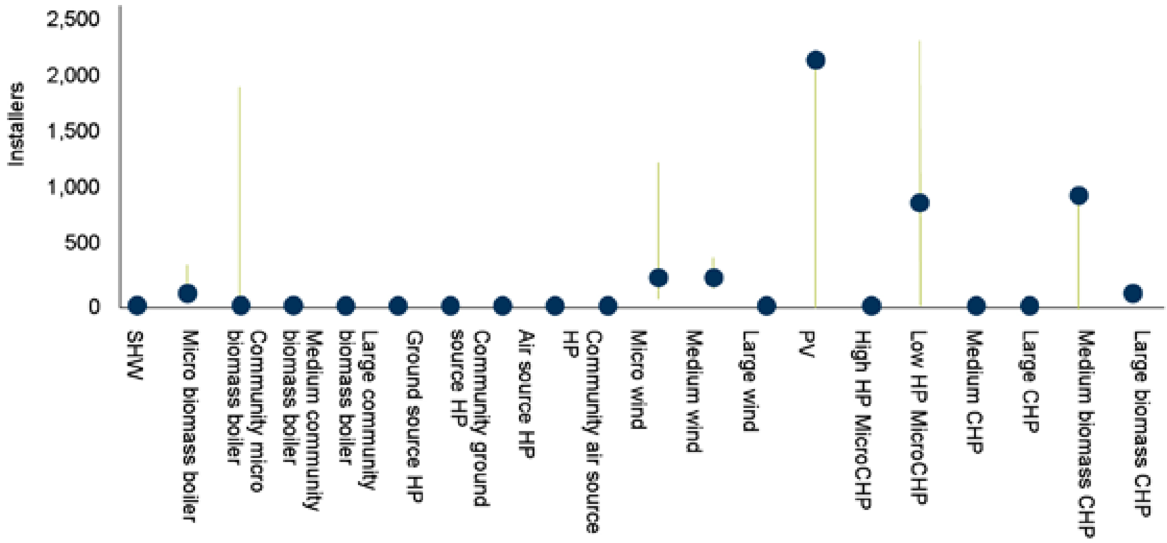
While at an overall sector level the majority of these workers are Polish, there is some variation at a sub-sector level, with workers from the Caribbean and the Southern Hemisphere dominating the migrant labour within the air-conditioning and refrigeration sub sector.[187] The transient nature of migrant labour may cause staffing issues (and therefore create skills gaps and shortages) for the sector going forward as many migrant workers may choose to return to their country of origin or move on to other countries which may offer more attractive employment opportunities in light of the current economic crisis.

The Element Energy baseline scenario (based on policies in place in 2008 including Renewables Obligations, 5 per cent VAT reduction, the LCBP programme etc) suggests that approximately 560 installers will be required by 2015, rising to 2600 in 2020. On the maintenance side, this model suggests employment will be lower at approximately 1,000 jobs a year in 2020 because the majority of installations will still be relatively new by 2020.[188] It should, however, be noted that Element Energy presents a range of forecasts which vary significantly as a result of the uncertainly related to the future impact of policies like Zero Carbon Homes and the planned Feed in Tariffs and Renewable Heat Incentives.

Figure 33 represents one scenario presented for employment to 2016 by RAB, which illustrates the range and the average number of installers. serves to illustrate the point that it is currently very difficult to estimate future employment in the sector, leading to RAB including large sensitivities on their estimates. Furthermore, whilst this does appear to at least highlight in which sectors the employment may arise, it should be noted that other forecasts suggest different deployment rates for each technology, which would shift the balance of employment.

[185] RAB (2007) The Role of On-site Energy Generation in Delivering Zero Carbon Homes
[186] SummitSkills (2008) Report on additional research into specific themes arising from the Sector Skills Agreement for building services engineering
[187] SummitSkills (2008) Report on additional research into specific themes arising from the Sector Skills Agreement for building services engineering
[188] Element Energy (2008) The Growth Potential for Microgeneration in England, Wales and Scotland

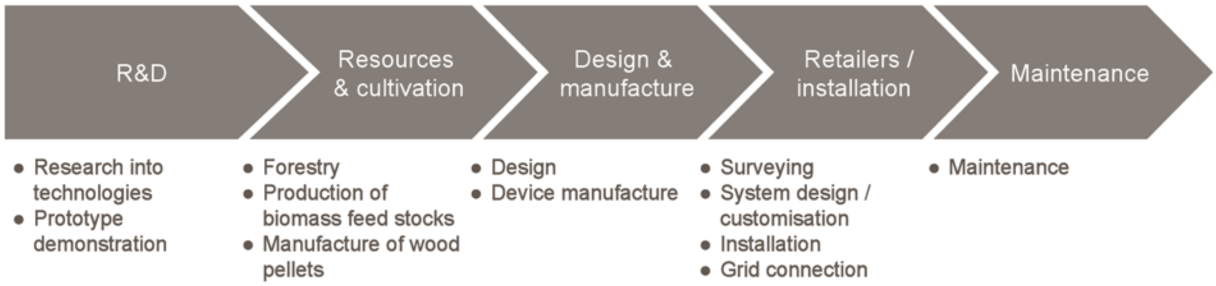
Figure 33: RAB Forecast for microgeneration installers to 2016 in the baseline scenario



Source: RAB (2007)
Note: The circle represents the baseline RAB estimate. The line illustrates the upper and lower sensitivity bounds.

The Renewables Advisory Board (RAB) has also forecast the requirements for installers in the market and their scenarios suggest requirements will range from 2,240 to 5,510 in 2016. Figure 34 provides an illustration of the microgeneration value chain.

Figure 34: Microgeneration value chain



Source: PwC analysis of stakeholder interviews

Table 16 shows how direct employment relating to microgeneration can be mapped onto the value chain.

Table 16: Mapping job functions onto the microgeneration value chain

Stage of value chain	Job function(2)	Direct employment in 2009	% of sub-sector employment
R&D and Design & manufacture	Design and manufacturing	170	17%
Resources & cultivation(1)	n/a	-	**-**
Retailers/ Installation	Construction and installation	660	66%
Maintenance	Operations and maintenance	170	17%
	Total Microgeneration	**1,000**	**100%**

Source: PwC analysis of stakeholder interviews and SummitSkills (2008) Report on additional research into specific themes arising from the Sector Skills Agreement for building services, Volume I: Research Findings
Note: (1) Resources and cultivation jobs have been excluded from our analysis of employment and subsequent scenarios because they relate to indirect, rather than direst employment.
Note: (2) We have estimated the breakdown of microgeneration activities across the value chain in the absence of existing research in this area.

7.4.1 Research and development

R&D in the UK is supported by funding through the Technology Strategy Board, Energy Technologies Institute, the Hydrogen, Fuel cells and carbon abatement technologies demonstration programme, the Carbon Trust, the Engineering and Physical Sciences Research Council (EPSRC), as well as through European funding bodies. [189]

The UK has a number of innovative microgeneration companies including Proven Energy and Quiet Revolution in the small wind sector.

7.4.2 Resources and cultivation (Biomass only)

The UK has a strong tradition for agricultural and forestry. The ability to produce appropriate biomass feedstocks within the UK will be dependant on these industries and how proactive they are at taking advantage of the new opportunities created by the microgeneration market. The UK biomass feedstock for energy generation market can be broken down as follows:

- 14 million tonnes from straw;
- 4.5 million tonnes from waste timber;
- 3 million tonnes from forest residue; and
- 3 million dry tonnes[190] of fuel for anaerobic digestion (e.g. slurry etc).

If heat generation from biomass sources increases significantly, it could help safeguard agricultural and forestry jobs resulting in a positive impact on the rural economy.

[189] BERR (2007) Microgeneration R&D funding
[190] These fuels are mainly made up of water and therefore the weight is usually measured in dry tonnes, i.e. weight once water is extracted.

7.4.3 Design and manufacture

A large proportion of microgeneration projects involve the installation of standard products, particularly for systems installed on residential properties. However, some of the larger scale projects require a degree of design and customisation.

The UK has a leading position is micro-wind, and domestic manufacturers supply 82 per cent of all small wind turbines installed in the UK. There are 18 small wind manufacturers in the UK, including Proven Energy (the world's second largest manufacturer), and five out of the top ten small wind manufacturers. The UK small wind market was valued at £13.5m in 2008, and businesses here export an estimated 50 per cent of production to over 100 countries.[191] Employment within micro-wind manufacturing is estimated to be around 400.[192]

In the solar market, Sharp has a significant manufacturing plant in Wrexham which has been producing solar modules since 2004 for the UK and European markets, although the UK still imports solar microgeneration technology from other countries including China. Of the systems installed under the LCBP, Sanyo was the primary manufacturer (40 per cent of products), and Sanyo, Sharp and Kyocera together accounted for 70 per cent of installations.[193] There are a number of UK companies operating in the UK solar thermal sector. Of the systems installed under the Low Carbon Buildings Programme (LCBP), Genersys Plc, Schott (Rayotec) and Thermomax, which are all based in the UK, had a strong presence.[194]

The UK also has a number of manufacturers involved in the design and manufacture of biomass boilers. These are primarily manufacturers of log stoves, but there are a small number of organisations involved in pellet boilers, workshop waste burners and straw burners for agricultural use.

There is a similar story in the heat pumps (GSHP and ASHP) sector and although there are a significant number are imported are imported from Sweden, China and Japan, there are a reasonable number of companies with UK operations including Calorex, Baxi, Dimplex and Vaillant.

7.4.4 Retailers/installation

As discussed previously, around 400 installers have been certified via the Microgeneration Certification Scheme. Research undertaken by the UK Energy Research Centre (UKERC) indicates that, there were at least 370 companies involved in the installation of microgeneration systems, under the Low Carbon Buildings Programme (LCBP), of which the largest share were in the solar thermal sub-sector (281). There were 60 companies involved in solar PV installation, 51 installing micro wind, 49 installing GSHP and 49 for wood fuelled systems.[195] These installers are typically focused on only

[191] BWEA (2009) Small Wind Systems UK Market Report
[192] BWEA (2009) Small Wind Systems UK Market Report
[193] UKERC (2009) Power to the People
[194] UKERC (2009) Power to the People
[195] UKERC (2009) Power to the People

one microgeneration technology, although between a third and a quarter of the companies installing the newer technologies also install the dominant solar thermal systems.[196]

Looking at the UK building services engineering sector as a whole, research conducted by SummitSkills in 2008 [197], found that the proportion of companies involved in installation varied across the different types of technology, as follows:

- Solar thermal systems 25 per cent
- Small-scale wind systems 4 per cent
- Biomass systems 5 per cent
- Ground source heat pump systems 22 per cent
- Air source heat pump systems 16 per cent
- Micro-hydro systems 2 per cent
- Fuel cells 2 per cent
- Combined heat and power systems 29 per cent
- Solar PV systems 6 per cent

In the wind sector, more than 75 per cent of the small wind turbines installed under the LCBP were one of three products; the 1kWp Windsave WS1000; the 5kWp Iskra AT5-1; and the 6kWp Proven Energy WT6000.[198] The Windsave and Iskra were each dominated by a single installer, while the Proven Energy device had a more diverse installer group. Employment in the installation of micro-wind is estimated to be around 750.[199] However, due to our reliance on secondary data sources, it is not clear whether these are new jobs or whether they represent the total FTE engaged in new micro-wind installation activities.

Installation is a key part of the value chain for the UK market, and is currently being undertaken by building service engineering companies who install traditional boilers and generators, as well as some new firms who have established themselves as renewables specialists:

> *"There are two sub-sectors [of building services engineering] involved in microgeneration: electro-technical and mechanical. The skills that are needed across the technologies within those sub-sectors are similar to those needed to install traditional technologies. Mechanical building services engineers (plumbers, heating engineers etc.) will install pipes and components and connect to hot water and heating systems etc. Electro-technical building services engineers will install cables, terminate cables, connect to the supply grid and so on." (Interview with SummitSkills)*

[196] UKERC (2009) Power to the People
[197] SummitSkills (2008) Report on additional research into specific themes arising from the Sector Skills Agreement for building services engineering
[198] UKERC (2009) Power to the People
[199] BWEA (2009) Small Wind Systems UK Market Report

This view is consistent with the findings of research undertaken by Element Energy, which suggests the requirement for installers and service personnel will be met by 'up-skilling' the existing workforce for conventional heating systems with short courses.[200]

There also appears to be common core skills across technologies. This is demonstrated in Table 17 which highlights the way installers have been installing multiple systems which are not instantly identifiable as being closely linked. For example, companies with the skills to install solar photovoltaic have not only been installing solar thermal, but also wind turbines and to a lesser degree, wood fuelled boilers.

Table 17: Installation of microgeneration under the Low Carbon Buildings Programme (LCBP)

Of the companies that install …	… only install that technology	GSHP	PV	… also install STHW	Wind	Wood
Ground source heat pump	76%	N/A	4%	25%	2%	4%
Solar photovoltaic	52%	3%	n/a	32%	25%	5%
Solar thermal hot water	78%	6%	9%	n/a	6%	7%
Wind turbine	69%	2%	29%	24%	n/a	4%
Wood fuelled boiler system	67%	3%	6%	33%	4%	n/a

Source: UKERC (2009)

To some extent, the demand for retrofitting of renewable technologies to replace traditional carbon rich technologies in domestic markets will be dependant on the backing of the installers. This means that manufacturers (and the UK Government) have a vested interested in encouraging plumbers to participate in training and certification schemes in microgeneration technologies. For example, buying a replacement boiler for a home heating system is usually an emergency purchase, with the installer as the first (and sometimes only point of contact). The consumer will choose a plumber on the basis of factors such as price, reputation, and availability and will often act on their advice regarding the type of boiler which they choose as a replacement. If this plumber is not trained or certified in the installation of renewable technologies then they are unlikely to recommend such technologies as that would result in a loss of business.

Overall, microgeneration installation appears to be carried out by a few hundred companies, each handling a limited number of installations each year. It is likely that, in the majority of cases, this is a sideline rather than being a core part of the job. [201]

[200] Element Energy (2008) The Growth Potential for Microgeneration in England, Wales and Scotland
[201] UKERC (2009) Power to the People

7.4.5 Maintenance

Maintenance requirements for the different microgeneration technologies are generally minimal. Solar thermal and solar PV systems require little more than to be kept clean, to have a yearly check by the householder and a more detailed check by a professional installer every three to five years. Ground source heat pumps have very few moving parts so servicing is required infrequently, and since there is no combustion involved, they do not require an annual safety check. Air Source Heat Pumps (ASHP) are one of the exceptions and require regular inspections by service contractors for filter replacement, cleaning of the coil, ductwork, and fan, and lubricating the motor. However, ASHPs currently represent a minimal share of installed capacity. Table 18 further illustrates that the servicing requirements for microgeneration appear minimal relative to the requirement for installation.

Table 18: Supply chain requirements for installation and servicing microgeneration technologies

Approximate labour requirement	Man days per installation	Man days for annual servicing
GSHP	3	0.1
ASHP	1	0.1
Stirling engine CHP	2	0.25
Fuel cell CHP	2	0.25
Biomass boiler	3	0.5
Micro wind	3	0.25
Small wind	5	0.5
Solar PV	3	0.1
Solar hot water	3	0.1

Source: Element Energy (2008)

According to our stakeholder interviews, companies involved in the installation of microgeneration technology are trying to build up networks of local companies with the capacity to provide maintenance services for these installations. This has to be done in a way which promotes high quality work, as failure to do so will reflect badly on the industry which will have a negative impact on future demand.

7.5 Current skills needs for the microgeneration industry

A significant proportion of the jobs in the microgeneration sector appear to be related to installation. There are synergies in terms of the skills required and in solar for example, solar thermal and solar PV have similar requirements in terms of roof mounted installation. The skills required for solar PV also overlap with small-scale wind installation because both often require roof mounted installation and involve electrical skills to manage the inverter operation. Furthermore, GSHP, wood fuelled systems and solar thermal require common plumbing skills.

Figure 35 illustrates the generic skill sets required for microgeneration installation.

Figure 35: Skills and trades associated with microgeneration and water recycling

Occupations, trades, skills	Relevant professional and trade bodies	Scope	Solar thermal	PV	GSHP	At source heat pumps	Wood heating	Energy from waste	Micro wind	Small wind	Micro hydro	Micro CHP (stirling)	Micro CHP (wood)	Micro CHP (fuel cells)	Grey water recycling	Rainwater harvesting
Plumbers and heating engineers	IPHE, CORGI, APHC, SNIPEF, IDHEE, CIBSE, HVCA	Installation Design	•••		•••	•••	•••	•••				•••	•••	•••	••	•••
Electricians	IET, ECA, NICEIC, Select	Installation		•••					•••	•••	••					
Electrical engineers	IET, CIBSIE	Installation, Design		•••					•••	•••	•••	•••	•••			
Civil engineers	ICE	Installation, Design			•					••	••					
Design & planning engineers	IET, ImechE, ICE, CIBSE, IPHE, EI	Installation, Design, Planning	••	••	••	••	••	••	••	••	••	••	••	••	••	••
Roofers	NFRC	Installation	•••	•••					•••							•
Drillers	BDA	Installation			•••											
AC & Refrigeration Engineers	ACRIB, FETA, HCVA	Installation & Design			•••	•••										
Solar Engineer	STA. IDHEE	Design Installation	•••													
PV Engineer	REA	Design Installation		•••												
Wind Engineer	BWEA	Design Installation							•••	•••						
Blomass Engineer	REA	Design Installation					•••	•••					•••			

Source: The National Energy Foundation (2007)

Our stakeholder consultations and review of the relevant literature indicate that qualified trades persons within building services engineering (e.g. electricians and plumbers with NQF Level 3) could acquire the additional knowledge necessary for the installation of microgeneration equipment relatively easily via a short training course:

> *"The actual practical skills [required] to install microgeneration systems are not that different from traditional technologies, but there is a need for additional underpinning knowledge in terms of system design, integration with other technologies and for some technologies; specific knowledge for health and safety in particular. From a building services engineering perspective and also from an MCS [Microgeneration Certification Scheme] perspective, it will very much be existing sector occupations that will up-skill and diversify to design and install microgeneration technologies rather than new occupations being introduced. It is paramount that the sector is supported in achieving the timely up-skilling of the existing workforce." (SummitSkills)*

The following vignette describes a career related to microgeneration technologies. It will be revisited in chapter 9 of this report to indicate how the role might develop over the next decade.

What qualifications do you hold?

I was an Apprentice Engineer with British Gas I have no other formal qualifications

Tell me a bit about your career to date.

I have only had two employers: British Gas and Worcester Bosch. I was with British Gas for 15 years. I started out as an engineer and ended as a supervisor.

I have been with Worcester Bosch (part of the BOSCH Group)for 23 years. During that time I've held three roles:

- Training Manager, which involved training of customers to the technicalities of our products;
- Business Development Manager for high efficiency products, which involved overseeing the introduction of the legislation changes of the Part L of the Building regulations (introduction of condensing only boilers); and
- Head of Sustainable Development (my current position), which entails industry and Government liaison.

What does a Head of Sustainable Development do?

With more and more of our business being influenced by legislation e.g. 20/20/20 targets, I endeavour to ensure that Worcester Bosch is both informed and has a say at the 'top table' on any areas that have a direct or indirect effect on our business and offer guidance on future business plans and product development.

Do you expect your role to change over the next decade?

I think this role will grow as there will be a need to find practical main stream solutions to climate change issues.

How do you see your career progressing?

I feel confident that my knowledge within the 'lobbing / networking' arena will become more and more needed and that youth is no advantage over experience. I therefore feel the role will only grow.

What impact has the drive to reduce carbon emissions had on your career path?

It has created a whole new career path, which previously did not exist within the heating / renewable manufacturing industry.

How did you become involved in renewables?

The involvement came about by the Governments drive for low carbon households and that BOSCH was already a market leader in these technologies in Europe.

What was your personal motivation for becoming involved in renewables?

I have only ever worked in the domestic heating industry and suddenly with households being one of the main areas needed for low carbon solutions, these two things have made me passionate about bring a realist approach to the issues.

Source: PwC interview with Neil Schofield, Head of Sustainable Development, Worcester Bosch

Electrical microgeneration technologies (solar PV, small scale wind, CHP etc) involve connection to the grid in the majority of cases. This requires specialist equipment and skills for connection and metering. During the installation process, some technologies including small scale wind turbines will require planning permission and structural surveys, which can lead to the involvement of architects, planners and potentially even lawyers.

Management and leadership, business acumen and entrepreneurship skills are an issue for the building services engineering sector in general,[202] and it may therefore also be an issue for those involved in microgeneration, which may restrict the productivity within this sub-sector. Stakeholder interviews also identified expertise in succession planning, given the large number of sole traders and family businesses in the sector, as a particularly important issue.

A report by SummitSkills for the Welsh Assembly Government suggests that despite the relatively low level of installation to date, 68 per cent of companies in Wales are having trouble recruiting fully qualified and experienced personnel in the microgeneration specifically and across the craft areas within the building services engineering sector generally and 73 per cent of companies have identifiable skills gaps in terms of the number of staff trained in microgeneration technologies.[203] Similar analysis does not currently appear to be available for the rest of the UK, so it is unclear if a similar trend is apparent across all four jurisdictions.

Overall, there is presently little evidence that significant skills gaps exist within this sub-sector. However, if demand for microgeneration increased significantly then there is the potential for a skills gap to emerge amongst the mechanical and electrical roles within the building services engineering sector, in the form of a lack of specialist knowledge of how to install, maintain and design microgeneration systems:

> *"The percentage of companies waiting for market stimulation suggests that any sudden increase in environmental technology use will lead to a heavy demand for training, which the supplier network will be unable to meet. The London region remains particularly vulnerable in this respect because of the high commitment to developing new technologies, the Olympics and the high number of proposed prestigious buildings in London which are likely to incorporate the most 'high tech' solutions."* [204]

[202] SummitSkills (2008) Report on additional research into specific themes arising from the Sector Skills Agreement for building services engineering
[203] SummitSkills and Energy&Utility Skills (2007) Skills Development Fund Application 2006-07
[204] SummitSkills (2008) Report on additional research into specific themes arising from the Sector Skills Agreement for building services engineering

7.6 Current provision of skills for the microgeneration industry

There are already a number of training courses for re-skilling trades persons, as shown in Table 19. Although as previously discussed, up-take of microgeneration training to date has been relatively low. This issue is explored in more detail below.

Table 19: Microgeneration training courses

Courses	Qualification	Provider
Solar Electric Systems	DIY/ Professional	Centre for Alternative Technology
Solar Water Heating Systems	DIY/ Professional	Centre for Alternative Technology
PV installation	City & Guilds unit 2372	Bedford College Blackburn College Empower Training Guildford College Redcar and Cleveland College Lews Castle College
Solar domestic hot water heating to assist in SCHRI accreditation	-	School of Construction Inverness College UHI
Solar electrical installations for professionals; Water heating systems for installers & DIY	-	Amersham & Wycombe College
Installation of solar hot water systems for experienced plumbers/ heating engineers	-	East Cheshire Training and Assessment (ECTA)
Solar water training course	Domestic Solar Hot Water Heating Systems certificate	BPEC
Interactive demonstrations, assembly kits, videos, posters, publications, workshops and events on Solar, solar cells, solar thermal, photovoltaics		Schools & home energy education project
Domestic wind and biomass markets	Level 2 VRQ	Northumberland College
EU Heat Pump Installer Heat Pumps	Plan to award CITB certificate. Subsequently input to NVQ system	The Grimsby Institute of Further & Higher Education
EU Heat Pump Installer Heat Pumps	Expect certification from Elecsa. Possibly also from Logic.	Glen Dimplex UK Ltd
Ground source heat pumps		Dundalk Institute of Technology
Ground source heat pumps		Logic Certification Ltd
Ground source heat pumps	Certificate of attendance	BBT Thermotechnology
Ground source heat pumps	Certificate of attendance	Ice Energy Heat Pumps Ltd
Ground source heat pumps	To be decided	Geothermal International Ltd
Ground source heat pumps		EarthEnergy Ltd
Heat Pumps	Certificate of attendance	Epogee Ltd
Heat Pumps		Centre for Alternative Technology

Source: EU Skills (2007) Occupational and Functional Map Renewable Energy Sector & The National Energy Foundation (2007) Identification of Renewable Energy Training Provision, Qualification Accreditation

In addition to this the UK has recently launched the Microgeneration Certification Scheme, which covers all microgeneration products and services. The aim of the scheme is to provide consistent standards and greater protection for consumers. In order to become certified products and installers are evaluated against robust criteria. Initial uptake was slow and some installers were discouraged by the cost and requirement to have formal quality management procedures in place. However, actions have been taken to address these issues: the increased number of certification bodies has reduced the costs; and a new fee structure has been put in place to speed up the certification process. To make the scheme more accessible to smaller firms and sole traders, the Department of Energy and Climate Change (DECC) now provides support and a short training course on how to complete the required quality processes.

The Renewables Advisory Board (RAB) has suggested that there is: a shortage of trainers for microgeneration courses; a lack of cohesion between courses; and a lack of recognition of all qualifications. This problem, they claim, is compounded by the fact that many courses are run by manufacturers, and focus specifically on their models.[205] It is likely that the lack of trained personnel and courses is a result of the uncertainty about future demand in the microgeneration sector.

> *"Current work by the Electrical Contractors Association (ECA) on a sustainability project aims to improve the quality and breadth of microgeneration courses, and integrate the sustainability issues into general apprenticeship schemes". (RAB, 2007)*

Significant growth is expected in the microgeneration sector which will require increased provision of training in the sector. However, the National Energy Foundation (NEF) suggests that the industry is likely to respond, reducing the Government involvement required to a general up-skilling of workforce across the energy and construction markets to NVQ Level 3.[206] NEF also indicates that there is a need to accredit training for microgeneration, but this requirement has largely been solved with the introduction of the Microgeneration Certification Scheme.

The Renewables Advisory Board notes that there is likely to be future need for specific specialist design-related skills in the future as the microgeneration market grows. Basic feasibility and design is likely to be carried out by the installer, but may require training for retailers, suppliers, with additional guidance from manufacturers.[207] These skills are likely to be especially important for district (community) heating systems and CHP.

Our interviews with stakeholders revealed concerns about future skills provision as, currently, course providers are unwilling to provide courses until the demand is apparent in the market. At the same time, employers in the industry are unlikely to invest in the training for their employees in advance of demand because of the cost of training. The concern is that a tipping point will be reached (possibly Zero Carbon Homes in 2016) and there will be a spike in demand for microgeneration installations, but that the industry and training providers will not be able to cope, both in terms of the supply of microgeneration systems or the supply of training.

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[205] RAB (2007) The Role of On-site Energy Generation in Delivering Zero Carbon Homes
[206] Element Energy (2008) The Growth Potential for Microgeneration in England, Wales and Scotland
[207] RAB (2007) The Role of On-site Energy Generation in Delivering Zero Carbon Homes

8 Industry foresight

Chapter summary

In our view, there will be five primary drivers of growth for the low carbon – particularly renewables – energy generation sector:

- Governance;
- Technology;
- Economic factors;
- Consumer demand; and
- Environmental change.

Governance encompasses Government legislation, regulation and the incentives that are being used to shape the market place and encourage private sector investment and participation. The Government's legal obligation to reduce greenhouse gas emissions by 34 per cent by 2020 (compared to 1990 levels), New Industry, New Jobs and its Renewable Energy Strategy, provide the impetus for the substitution of fossil fuels as the main source of energy generation and for the overall growth of the market.

Technology is also a key driver in particular for renewables (nuclear can be considered a well proven technology). Different renewable technologies are at very different stages of development; wind is relatively proven, notwithstanding the need for larger scale wind farms further off-shore in deeper waters; but marine/tidal, and carbon capture and storage are at a much earlier stage of development. Microgeneration is somewhat mixed. The rate at which these technologies can be deployed will be a major determinant of future employment across these sectors. There is mixed evidence regarding consumer demand for clean energy and their concerns around the environmental impact of fossil fuels, as individuals and companies are still primarily driven by a desire for cheaper energy – a desire that will be exacerbated in the short-term by the recession and by current high energy prices. Barriers to growth in the sector relate mainly to:

- Access to finance;
- Planning consent;
- Current infrastructure; and
- Supply chain weaknesses.

Access to finance has been evidently exacerbated by the credit crunch. There are also some issues with the existing system of ROCs that mitigate against successful raising of finance. While it is hoped that the new Infrastructure Planning Commission will alleviate some of the planning approval issues, serious concerns remain, particularly with regard to finance and the supply chain. The low level of manufacturing capability in the UK has been raised many times in this research as has the need to better exploit our research and development in these new technologies.

The Government has made a clear commitment to driving forward the skills agenda in the low carbon sector. It is clear from our research that such an active approach will be required to achieve the necessary growth in the low carbon energy generation sector.

Indeed, as the recently published National Skills Strategy states, a Sector Skills Accord between employers, sector bodies and awarding bodies (led by the British Wind Energy Association as part of the renewable energy strategy) was signed in October 2009. This Accord includes employer commitments such as resources to develop industry specific National Occupational Standards and qualifications, new apprenticeship frameworks, career pathways and enhanced STEM guidance.

There is a clear consensus that, these barriers notwithstanding, that employment in the sector will grow. While we consider the magnitude of this growth in 2020 under three different possible scenarios in the following sections, it is clear that this growth will require a suitably qualified workforce. While this workforce will need to be fed from STEM graduates, there is of course an experienced pool of workers in the UK off-shore oil and gas industry that have transferable skills that are applicable for example in the development and installation of off-shore wind farms, in marine installations, or in the storage of CO2 in off-shore North Sea oil and gas reservoirs. Therefore, to some extent, employment growth in this sector could counteract the decline in employment by more traditional energy generation. Projections for the demand and supply of STEM graduates over the next decade demonstrate a significant shortfall in the numbers of engineers and scientists required to drive growth. In this context, the low carbon sector will need to compete for STEM graduates from industry as a whole.

It is less clear whether many new jobs will emerge in the manufacturing sector, at least in the short-term. There is a prevalent view that it may be too late to re-establish a manufacturing base to meet the short-term demands of the wind sector – but marine and carbon capture and storage are at a much earlier stage and may still represent good long-term opportunities.

8.1 Introduction

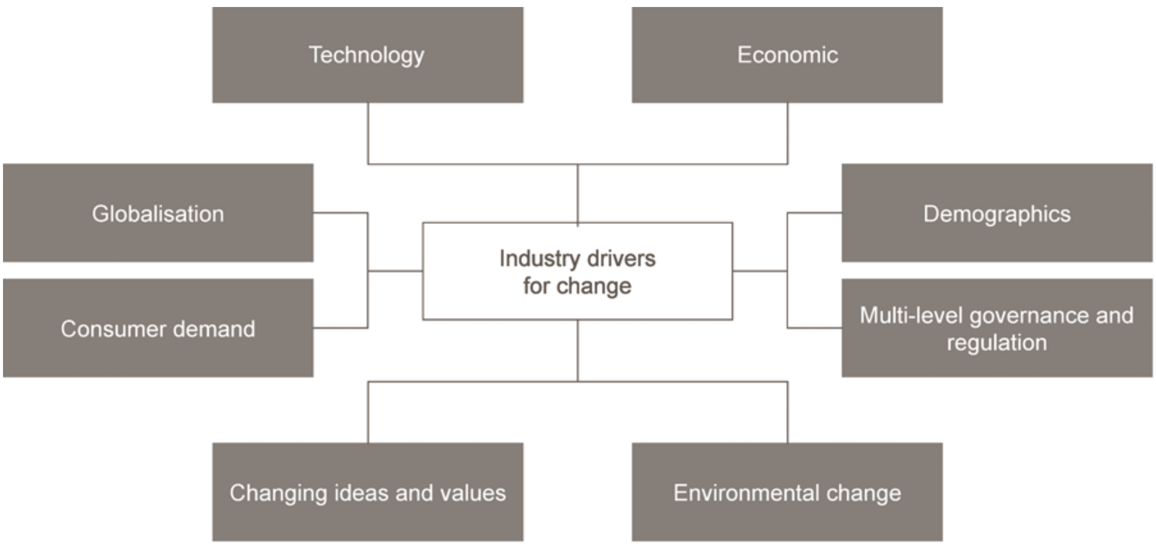
This section of our report presents our analysis of the key drivers for change in the low carbon energy generation market in the UK over the next 10 years, potential barriers to growth, and the likely implications for employment and skills. It is based on extensive desk research and consultation with our internal PwC renewables team, the relevant Sector Skills Councils and other industry representatives, as well as a number of key players in the industry. It is therefore structured as follows:

- Key drivers for change in low carbon energy generation;
- Barriers to low carbon energy growth;
- Implications for future employment and skills;
- Implications for future skills provision; and
- Conclusions.

8.2 Key drivers for change in low carbon energy generation

In the context of the wider National Skills Audit work, a number of key industry drivers for change have been identified. These drivers, which are illustrated in the diagram below, have formed a framework for the basis of not just our study but the other projects stemming from the Audit.

Figure 36: Drivers for Change



Source: PwC analysis of stakeholder interviews

This framework provides a useful means of comparing and contrasting the main drivers across different sectors, and each driver will be interpreted in slightly different ways to reflect the nature of the industry under scrutiny. For low carbon, for example, our research suggests that the main drivers are as follows: governance; technology; economic; consumer demand and environmental change. In the following chapter of this report, we present three scenarios based on two axes derived from these key drivers: firstly governance defined as both Government support and legislation; and secondly, "innovation" which is intended to encompass not only advances in technology but also the appetite in the private sector to respond to the opportunities offered by the new technologies (stimulated by both the "economic" and the "consumer demand" drivers).

Each of these drivers is discussed in further detail below.

8.2.1 Governance drivers

The UK has a legally binding obligation to reduce greenhouse gas emissions by 60 per cent below 1990 levels by 2050, and by 34 per cent by 2020. As we noted in the Industry Insight: Overview section, low carbon is now a high priority for the Government, with a result that several key policy documents have been launched in the last year.

The Low Carbon Transition Plan and the Renewable Energy Strategy (both 2009) outline the Governments plans to generate 30 per cent of electricity from renewables by 2020 (with a focus on wind, bioenergy, hydro, wave and tidal), 12 per cent of heat from renewables (with a focus on non-domestic applications), and 10 per cent of transport energy from renewables.

Government support for low carbon is in response, not only to the globally recognised need to reduce greenhouse gases, but also because the low carbon sector has been identified as a key growth area, with the potential for jobs creation and GDP growth. As a result, there is a renewed focus on supporting renewable energy within the UK, with changes to legislation and creation of new focused Government offices, by establishing tariffs and by providing funding for research and commercialisation projects.

> *"The UK was the first country in the world to legislate for carbon budgets. It was a dramatic change in approach." Ed Miliband, Secretary of State for Energy and Climate Change*

8.2.1.1 Financial support for low carbon

Government tariff support was initially offered through Renewables Obligations Certificates (ROCs) which were introduced in 2002, but following the Stern Review in 2006, Feed in Tariffs (FITs) have been developed for rollout in April 2010. FITs are based on the German model, which is commonly cited as the primary driver of microgeneration uptake in that country.

In addition, Renewables Heat Incentives are planned for April 2011 to drive uptake of heat microgeneration technology. The Government announced a range of policies as part of the 2009 “Green Budget”, including:

- £525m support for off-shore wind projects through ROCs;
- £405m for green manufacturing to develop the wind and marine value chains in the UK;
- £90m funding for CCS, £45m for small scale renewables, and £25m for low carbon community heating; and
- A commitment to build between two and four CCS demonstration plants.

A number of other Government backed funding programmes support low carbon technology including the Marine Development Proving Fund, the £22m Marine Renewables Proving Fund, and research through the Technology Strategy Board and the Energy Technologies Institute.

8.2.1.2 Legislation

There are various legislative measures in place to support low carbon generation. In the carbon capture sector, the Government has announced this year that no coal plants will be constructed in the UK unless they can demonstrate CCS from the outset. In the microgeneration sector, the Code for Sustainable Homes (CSH) legislation requires that the carbon efficiency of new properties must be improved by 25 per cent by 2010, by 44 per cent to 2013, and by 2016, new residential properties should be zero carbon.

In October 2009, the Government also launched the Infrastructure Planning Commission (IPC) as part of the Planning Bill to help overcome some of the constraints on developing new sites. The IPC is an independent body, which will be responsible for decision-making in relation to infrastructure projects of national importance. The focus of the commission will be larger-scale projects: initial projects include five major wind farms, two new nuclear plants, a biomass plant and two National Grid connection projects.[208] The new planning system is expected to reduce timeframes for decisions on proposals over 50MW (100MW off-shore) to one year.

8.2.1.3 Infrastructure

In addition to the legislative and funding support, the Government has established the Office for Renewable Energy Development (ORED) to secure investment in the UK renewables supply chain and the IPC, and has plans to create an Office for Carbon Capture and Storage.

In the nuclear sector, the Office for Nuclear Development (OND) was established in September 2008 with the aim of making the UK one of the most attractive places in the world to invest in nuclear energy.

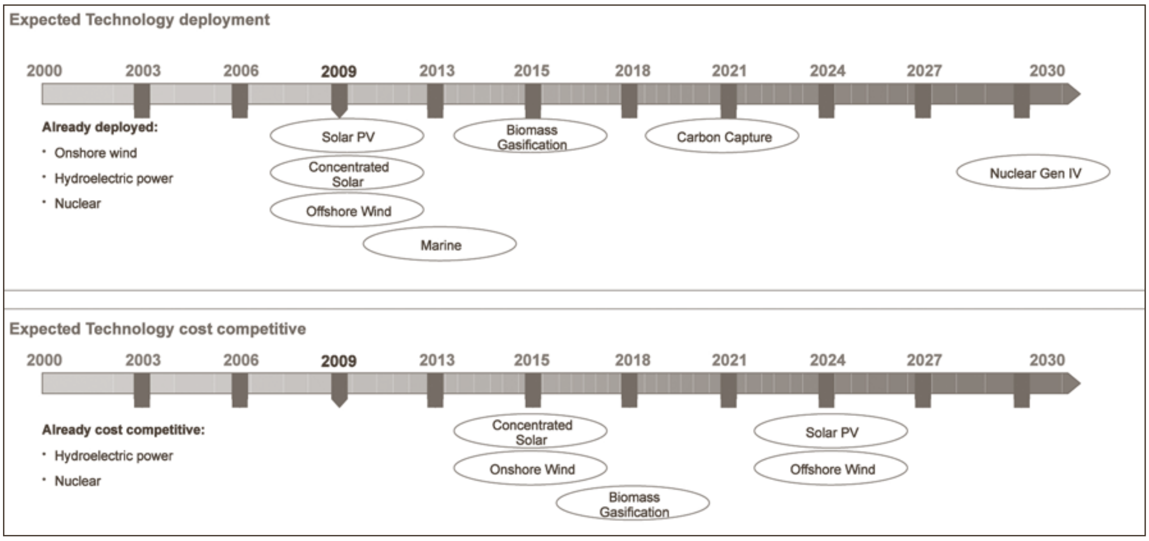
[208] The Gov Monitor website, 23rd October 2009 (see: http://thegovmonitor.com/world_news/britain/uk-infrastructure-planning-commission-names-initial-projects-11904.html)

8.3 Technology drivers

The low carbon energy generation sector is in a relatively early stage of development and the majority of renewables are dependant on subsidy support to compete with traditional fuels. As global deployment of low carbon generation technologies increases and as research breakthroughs are made in each of the respective fields, the unit cost of deploying each technology is expected to decline.

Figure 37 illustrates that some of the technologies considered in this report, including CCS and Marine, may only come online in 2020, so the impact these sectors have on employment and skills may be less apparent in 2020. Nevertheless, the longer time horizons required to overcome skills shortages and gaps mean that some consideration should be given to these emerging sectors sooner rather than later.

Figure 37: Low carbon energy generation technology maturity



Source: World Business Council for Sustainable Development (2008)

Technology is a broad driver and includes the scale of technology breakthroughs, and economic/ technical feasibility of technologies. Technology relates closely to the level of private investment in the UK value chain because if the technology reaches the level where it has a proven or high probability of economic returns, UK industry and overseas manufacturers could be expected to invest in the UK to take advantage of the growth in the UK market. Several key renewable technologies are at relatively early development stages, including marine (wave and tidal), Carbon Capture & Storage (CCS) and to a lesser extent, off-shore wind. The UK currently has strong positions in these markets, particularly in marine and CCS, and is leading research efforts to commercialise these technologies.

The sections below consider, in greater detail, the main technological drivers in selected low carbon sub-sectors.

8.3.1.1 Wind

On-shore wind is a relatively mature renewable technology across the world, although research is ongoing to reduce the costs and to develop more efficient designs. In the off-shore wind market, the technology is still evolving, and research is underway for larger turbines (10MW+) and new foundation designs for deepwater wind farms, which will further enhance the potential for wind energy in the UK.

8.3.1.2 Marine

In the marine sector, the UK has a leading position in the research and testing of wave and tidal systems, but no commercially viable technologies have been developed to date. The first devices to export power to the grid were the OpenHydro tidal farm in May 2008 and the Pelamis Wave Energy Converter, both at the European Marine Energy Centre (EMEC). The world's first commercial wave power project was launched in September 2008 in Portugal using three wave devices developed by Pelamis in the UK. Pelamis moved to Portugal due to difficulties in getting planning permission in UK.

However, all three turbines were removed in November due to technical problems, and then insufficient financial support was available as a result of the global financial crisis to re-launch the units.[209] E.ON has plans to test a new generation of the Pelamis system at EMEC in 2009-10.[210]

Another marine project which has been in the development and planning stage for some time is tidal range technologies (barrages and lagoons) in the Severn Estuary. The Government is currently carrying out a consultation into the different options and has created shortlist of five projects which have the potential to generate between 1.6Twh and 16.8Twh (5 per cent of UK electricity) per year.[211] It is, however, unlikely that, if the project does goes ahead, that the site would be operational before 2020 as after a second consultation in 2010, the planning and consent process would take between three and five years and construction could take up to another seven years.[212]

Overall, the Carbon Trust has suggested that wave and off-shore wind power are proportionally more important to the UK than the rest of the world and in both technologies, the UK is one of a small group of countries leading research and development.[213] The UK therefore could play a leading role in the deployment of these technologies globally.

[209] Cleantech group website, 17th March 2009 (see: http://cleantech.com/news/4276/pelamis-sinks-portugal-wave-power-p)
[210] E.ON website, (see: http://www.eon-uk.com/generation/1716.aspx), last accessed 1st December 2009
[211] DECC website, (see: http://severntidalpowerconsultation.decc.gov.uk/feasibility_study_overview), last accessed 1st December 2009
[212] DECC website, (see: http://severntidalpowerconsultation.decc.gov.uk/feasibility_study_overview), last accessed 1st December 2009
[213] Carbon Trust (2009) Focus for Success: A new approach to commercialising low carbon technologies

8.3.1.3 Microgeneration

The emergence of smart grids has the potential to revitalise the microgeneration market. Currently under consideration by Ofgem, a smart grid allows users to monitor electricity consumption in their household and enables utility companies to adjust energy prices in real time to reflect changes in supply and demand. Smart appliances connected to the smart grid can change consumption patterns depending on spot prices to enable better grid balancing. For example, if there were to be a shortage in power supply, the spot price of electricity would increase and trigger smart appliances to go onto standby, or the utility provider could even switch off appliances remotely. Smart grids also ease the process of exporting electricity back into the grid from microgeneration technology, which may ultimately contribute to increased deployment.

8.3.1.4 Carbon Capture and Storage

Carbon Capture and Storage (CCS) is emerging as a key technology to reduce emissions from fossil fuelled plants. The UK has a strong position in the CCS market and several demonstration plants are expected to be online by 2014, but there is considerable competition from other countries including the USA, China, Australia, Canada, Norway and the Netherlands. The USA has already awarded $3.5bn to CCS projects and Norway announced at the Carbon Sequestration Leadership Forum (CSLF) in October 2009 that it is planning to raise annual investment in CCS to a record $621m in 2010. In light of concerns about the future of UK Government support for CCS, these investments raise questions about the potential for the UK to lead the market in this technology.

8.3.1.5 Alternative future solutions

A number of alternative future technologies are also under consideration. These include the Desertec Project which involves the installation of Concentrating Solar Power (CSP) technology in the Sahara Desert, with the electricity generated being transported to Europe, the Middle East and North Africa by High Voltage Direct Current (HVDC) cables. This project aims to provide 15 per cent of Europe's energy requirements by 2050, and could significantly change the landscape of European energy generation in the longer term future.

One of the challenges commonly cited for renewable energy is the intermittency of natural resources, and the need for backup fossil fuel or nuclear power stations. However, the UK is currently in discussions with Norway to link electricity grids with the world's largest subsea power cable to share power generated from wind farms in the North Sea and hydropower from Norway. A pre-feasibility study has already been carried out which suggests the concept is technically and economically viable, but further research is required before an investment decision can be made.

There are other options being proposed for a European supergrid to create a network to link Europe with HVDC cables. The evolution of the European grid network has the potential to eliminate the need for backup fossil fuel power stations, and increase the penetration of renewable technology.

8.3.2 Economic drivers

European dependence on imported fossil fuels has been increasing, and the situation is forecast to deteriorate, with an estimate of more than 60 per cent of fossil fuels imported by 2020. The recent dispute between Ukraine and Russia has illustrated the potential for disruptions in future supply, with a consequent risk that some energy-rich countries may use energy as a political weapon. Energy security concerns have impacted fossil fuel prices, making low carbon technology an attractive solution to utility companies who are likely to struggle to continue passing energy price rises through to consumers. Additionally, although there is no immediate shortage of oil or gas reserves, demand will continue to rise, assuming China, India and other developing economies resume growth. The remaining fossil fuel supplies are also situated in less economically viable areas, where the higher costs of extracting these reserves are already pushing up energy prices.

8.3.3 Consumer demand drivers

A survey by Ipsos Mori in 2006 suggested that global warming was thought to be the most serious threat to future well-being in the world.[214] However, cost remains an important concern for consumers and a Powergen study in 2003 reported that consumers believe that "renewable energy should be cheaper than more polluting forms of energy". A second Powergen study in 2004 also suggested that the main reason for consumers making energy efficiency improvements to their homes was the potential cost savings. Furthermore, research by Element Energy[215] into the growth potential for microgeneration technologies, which studied consumer attitudes towards low carbon technologies, suggested that environmental concerns including reducing CO2 emissions were not a priority concern for consumers when replacing heating systems, and that the primary reason for considering microgeneration technology was to reduce energy bills.

A key theme emerging from research is therefore that, although consumers are concerned about the threat of global warming, the primary motivation for adopting low carbon improvements is the potential for cost savings, and that consumers are generally unwilling to pay a premium for low carbon solutions. This evidence suggests that low carbon technology is highly dependant on Government support, as few, if any, of the microgeneration solutions are currently cost-competitive without grant-aid. Consumer demand is therefore currently a minimal driver of low carbon energy.

8.3.4 Environmental change drivers

The United Nations Intergovernmental Panel on climate change projects that average global temperatures could increase by up to 6 per cent, which would lead to dramatic climate shifts including melting ice caps, changes in weather patterns and flooding. Much of this projected increase in temperature has been attributed to CO2 emissions. World leaders have therefore focused on the need to reduce CO2 emissions in order to minimise the negative impact on the environment.

[214] Low carbon life website, (see: http://www.lowcarbonlife.net/downloads/Edinburgh_presentations.pdf), last accessed 1st December 2009
[215] Element Energy (2008) The Growth Potential for Microgeneration in England, Wales and Scotland

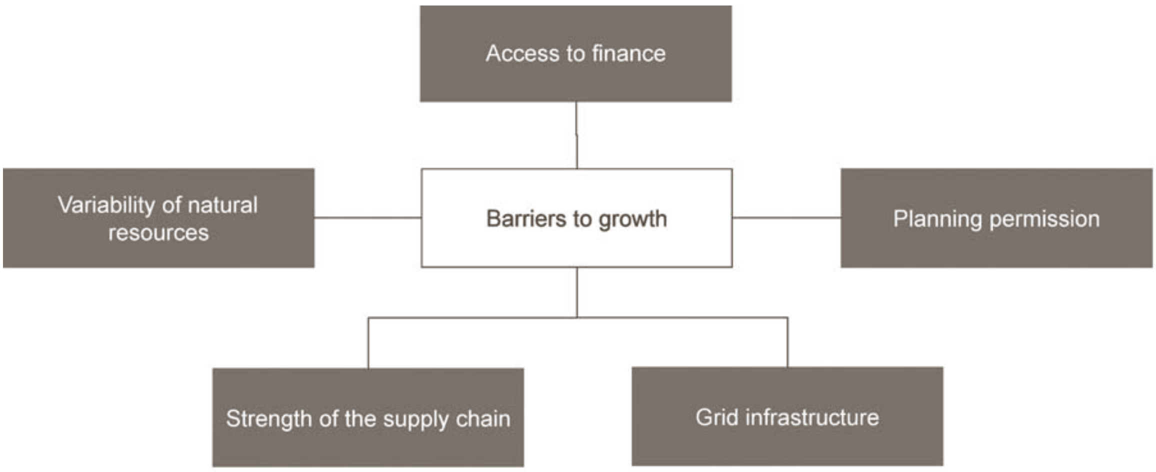
8.3.5 Summary of key drivers for change in low carbon energy generation

Our analysis suggests Governance is the key driver because the Government has taken an increasingly active role in the UK low carbon energy market with both legislative and financial support. Technology is the second key driver as technology breakthroughs and the level of private sector involvement to support deployment could have a decisive impact on market growth and the development of a UK value chain. There is also, evidently, an element of interdependence between the drivers and the significant level of Government support currently in place is in part a result of the energy security threat mentioned in the economic section above.

8.3.6 Barriers to low carbon energy growth

Alongside these drivers for change in the sector, our desk research and fieldwork have revealed a number of barriers to growth in local carbon energy generation in the UK. These barriers are illustrated in Figure 38.

Figure 38: Barriers to Growth



Source: PwC analysis of stakeholder interviews

8.3.7 Access to finance

Access to finance emerged as a critical barrier to the development of low carbon energy generation as a whole. This barrier was also the main obstacle identified in research with the industry undertaken by PwC on behalf of DECC this year, which revealed the main financial concerns as:

- The funding gap (the "Valley of Death") between applied research and large scale development/ demonstration projects;

- Raising equity in an uncertain regulatory framework;
- Raising equity due to the credit crunch;
- Cash flow problems as large scale investment might be needed before the grant has been received from the government;
- Access to private sector funding at early stages of research as venture capitalists are risk averse;
- Intellectual Property (IP): venture capitalists are discouraged by requirements by public sector funders to share IP;
- Investment/funding is not guaranteed for long periods of time (e.g. three years plus) which makes it difficult for developers to make long term decisions and create robust business plans;
- Public sector publishes reports received from the funded party which helps the developers' competitors; and
- As with other sectors, it is difficult for SMEs to start up in the sector (PwC, 2009).

The low carbon energy generation technologies considered in this report are generally characterised by high initial capital requirements and tend to have high risk profiles. Commercialisation is supported by Government tariffs, including Renewables Obligation Certificate (ROCs) and from 2010, Feed in Tariff (FITs). While FITs are expected to support growth of microgeneration technologies, EEF (a manufacturers' organisation) suggests the current system of ROCs needs to be reformed to support growth of large scale technologies. The current scheme generates a variable market price for renewable electricity, making it difficult to forecast revenue and therefore reducing the attractiveness of investment in the sector.[216]

Tariff support is a mechanism to improve the potential for return on investment in the longer term, but developers also require a combination of public and private funding for the day-to-day operations to ensure the business survives to the commercialisation phase. Evidence on the impact of the credit crunch shows a mixed story. On one hand, there is evidence of renewables projects being postponed or abandoned, with a survey by the Renewable Energy Association in April 2009 suggesting that three quarters of respondents faced significant problems gaining access to investment and loans.[217] However, NewEnergyFinance has reported that growth in developing markets has meant overall renewables investment has increased 5 per cent to £94bn, and that the challenges created by the financial crisis have resulted in projects changing ownership rather than being scrapped in the wind sector. It should also be noted in this context that the Government is under pressure to cut public spending, which may also have a knock-on effect for public renewables financing.

[216] EEF (2008) Delivering the low carbon economy

[217] REA Website, 6th April 2009 (see: http://www.r-e-a.net/info/rea-news/green-companies-facing-financial-crisis/)

A further challenge identified by BWEA is that there are numerous investment funds, and the complexity of identifying the most appropriate scheme can be very time consuming.[218] Public investment in UK renewables R&D is currently not in the same league as that which led to the development of the solar industry in Japan, or the wind industry in Denmark. These countries each invested over £1bn in the early stages of the industry. The BWEA has stated, for example, that the current UK support for marine energy is insufficient to develop a world leading industry. [219]

Stakeholders reported that access to finance is a critical barrier to development in the wind sector. This has been exacerbated by the current economic difficulties, which has led to a reluctance on the part of banks to finance new projects. Furthermore, high commodity prices (for steel for example) and a strong depreciation of the pound against the Euro, has increased the relative cost of importing turbines from EU countries. The economic feasibility of off-shore wind farms is currently under review and the success of the wind projects currently being installed may have a decisive impact on future off-shore projects. According to the British Wind Energy Association there are "up to £10bn of 'shovel-ready' wind power projects being held up by the current economic difficulties, £2.5bn of which would be spent directly in the UK on installation and construction work". This amounts to £6bn or 2GW off-shore and £4bn or 3GW on-shore projects. [220]

8.3.8 Planning consent

In the course of this study, issues relating to planning permission for energy plants emerged as a significant barrier to growth, particularly around the localised nature of planning process and local opposition or "Nimbyism".

> *"The decentralised planning process in the UK is one of the major reasons renewables rollout has been faster in other European countries. It is alien in other countries to have local communities opposing infrastructure projects because energy projects in other European countries are put in place by central government." Stakeholder Interview*

Local council planning permission approval is a key area of concern for renewables projects, particularly in the wind sector. A report released by BWEA in October 2009 highlights that approvals of wind farm applications have fallen to a new low of just 25 per cent, down from 63 per cent in 2007.[221] Planning permission has been cited as one of the major contributing factors to Vestas, (a leading Danish wind turbine manufacturer) closing its UK operations. Furthermore, even when planning does go ahead, it can be a very time consuming process and only 7 per cent of wind applications achieve a decision within the statutory four month period. [222]

[218] BWEA, (2009) Marine Renewable Energy, State of the Industry Report
[219] BWEA, (2009) Marine Renewable Energy, State of the Industry Report
[220] BWEA (2009) Powering a Green Economy
[221] BWEA (2009) Press Release (see: http://www.bwea.com/pdf/press/PR20091020_25pc_approval.pdf)
[222] New Energy Focus website, 20th October 2009, (see: http://www.newenergyfocus.com/do/ecco.py/view_item?listid=1&listcatid=105&listitemid=1840)

The Government launched the Infrastructure Planning Commission (IPC) in October 2009 as part of the Planning Bill to help overcome some of these constraints. It is an independent body, which will make decisions about infrastructure projects of national importance. The IPC will focus on larger projects: initial projects include five major wind farms, two new nuclear plants, a biomass plant and two National Grid connection projects.[223] The new planning system is expected to reduce timeframes for decisions on proposals over 50MW (100MW off-shore) to one year.

"Under the current regime, there is enough renewable energy caught up in the system to power over one and a half million homes. In the future now that the Planning Bill has Royal Assent we can begin to create the faster, fairer planning system needed to reduce fossil fuel addiction. Many low carbon power sources will now get faster approval." Hazel Blears, Communities Secretary [224]

8.3.9 Grid connection issues

"Access to the electricity grid has been one of the key barriers to the generation of renewable energy in this country." Ed Miliband, Secretary of State for Energy and Climate Change

Another problem relates to the current system of grid connection in the UK, which is currently based on a 'first come, first served basis'. Wind farm developers, for example, often complete their projects much faster than traditional coal or nuclear projects, but because of the hurdles faced with planning permission, they are reluctant to apply for grid connection before receiving the permission. In some cases, it can take several years to be connected to the grid.[225]

The EEF suggests that grid connection could be a challenge for renewables deployment, particularly in marine because the best wave and tidal resources are generally located in more remote parts of the UK where there is a more limited electricity transmission and distribution infrastructure. [226]

"The UK grid system is currently based on a centralised system (in simple terms, it's like a ring running around the centre of the UK). This works well with the current system of fossil fuel power stations, but is not suited to off-shore wind or marine technology that is generally located several miles off-shore… "There is a wind project in Lewis, Scotland, which has very strong wind conditions. However, it is located a long way from the National Grid, so the wind farm size needed to be significant to justify the high cost of installing a cable to connect this wind farm to the grid." PwC Renewables Team

"The North and West of Scotland have abundant marine energy resources but are heavily constrained by available grid capacity. The local distribution is sparse and there is limited capacity to accommodate generator connections." BWEA State of the Industry Report, 2009 [227]

[223] The Gov Monitor website, 23rd October 2009, (see: http://thegovmonitor.com/world_news/britain/uk-infrastructure-planning-commission-names-initial-projects-11904.html ojects-11904.html)
[224] Communities and local Government Press Release (2008) Planning Bill green light will accelerate renewable energy
[225] Business Green, 25th August 2009 (see: http://www.businessgreen.com/business-green/news/2248434/miliband-moves-address-wind)
[226] EEF (2008) Delivering the low carbon economy
[227] BWEA (2009) Marine Renewable Energy, State of the Industry Report

8.3.10 Supply chain shortages

Growth in the low carbon energy generation sector in the UK is expected to be rapid, but across many industries questions have been raised in relation to whether the value chain is in place in the UK (or even globally) to meet the forecast levels of demand. In the nuclear industry, there are only a few places in the world with the capability to manufacture large forgings or reactor pressure technology for example.

I n the wind sector, the perceived lack of port capacity may constrain the delivery of off-shore wind projects from continental manufacturing sites, and may even affect deployment of CCS and nuclear programmes according to a DECC report on UK ports. [228]

A common problem identified across the low carbon sectors is that UK businesses are reluctant to make the required initial investment in training and equipment etc until the demand is immediately apparent, especially in the current economic climate. Conversely, overseas manufacturers are reluctant to either establish UK operations or use UK suppliers until there is proven UK capability and capacity.

In the wind sector a specific problem identified is the shortage of installation vessels. It takes approximately nine months to modify an existing vessel or two to two and half years to commission a new vessel. There is a limited supply of these vessels globally and there are none currently based at UK ports. Another challenge is the increasing competition from other European wind farm projects (especially in Germany) for limited resources across the supply chain.[229]

Ultimately, deployment of low carbon energy generation technologies is being ramped up worldwide, which is likely to cause supply shortages as manufacturers scale up their operations to meet demand. In the nuclear sector for example, the Nuclear Energy Agency estimate that 12 new reactors will be built a year from 2007-30, increasing to 23-54 reactors a year in 2030-50. [230]

8.3.11 Variability of renewable resources

The intermittent nature of wind and solar energy is a topic of debate in the renewables sector. This issue primarily relates to wind in the UK because solar deployment is relatively low, and other low carbon technologies like marine, biomass, CCS and nuclear do not suffer from variability in the same way. Wind energy can be described as an unpredictable source of energy and the electricity generated is currently not storable, so there are concerns that a high penetration of wind power would raise continuity of supply issues unless investment is made in standby plants.

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[228] DECC (2009) UK Ports for the Off-shore Wind Industry: Time to Act
[229] BERR (2008)Supply Chain constraints on the deployment of renewable technology
[230] DECC (2009) UK Renewable Energy Strategy

However, industry experts suggest this may not be as big a barrier as suggested in some quarters. If the electricity system is structured in a way that considers the variability of both energy supply and demand, there is the potential for renewables to represent a significant share of energy capacity. Two key industry developments which may have a considerable influence on this area are European super grids and smart grids.

As we have noted, the UK is in discussions with Norway to link the electricity grids of the two countries, enabling the sharing of electricity from wind farms in the North Sea and the less variable hydropower from Norway. There have been several proposals for European super grids, which would enable greater inter-country supply, because if wind speeds are low in one location in the UK, they are likely to be higher in other parts of the UK, or other parts of Europe.

Furthermore, smart grids are expected to be part of the UK's future energy distribution system, and these would allow better management of electricity supply and demand. A European supergrid is unlikely to be in place before 2020, but this has the potential to influence the longer term low carbon energy strategy.

8.4 Summary of barriers to low carbon growth

The main barrier to growth identified in the course of this research is access to finance and funding issues in general. Planning permission processes and problems with connecting to the grid were also identified by the industry in this regard. These barriers were also reflected in interviews and workshops undertaken with low carbon employers by PwC in early 2009 for the Department of Energy and Climate Change. In this research, a number of other, related, barriers were also identified – including, in relation to this study, difficulties in recruiting and retaining suitably trained staff (DECC, 2009). The main barriers identified in this report corroborate many of the barriers identified above:

- Uncertainty concerning the UK's future low carbon policy direction – despite the clarity of the Government's targets for reducing carbon emissions, there was perceived to be a continuing lack of conviction about the Government's climate change policy and in particular the intention of Government to support challenging targets with a commensurate level of funding support;
- No clear leadership – it was recognised that the creation of the Department of Energy and Climate Change was an important move in making UK policy in those two areas more coherent but the Department is still viewed as a new creation and there was uncertainty about its future direction;
- Lack of a long term carbon price – this was viewed as a function of the 'uncertainty' barrier mentioned above;
- The Government focus on renewables rather than low carbon was raised as an issue as it restricted access to Renewables Obligation Certificates and inhibited investment in technologies that would deliver the Government's carbon reduction goals by means other than pure renewable technologies;

- The funding gap ("Valley of Death") between applied research and large scale development/ demonstration – where technologies that have typically been developed to validation in a laboratory environment, often with public sector funding fail to receive support through to pre and post commercial deployment when private sector funding would normally take over;

- The UK's electricity network and infrastructure – which have historically been underinvested in and which are often incompatible with low carbon energy supply technologies; and

- Inadequate manufacturing capability within the UK as a pull factor for the market - on a sub-level any companies providing components for low carbon energy supply technologies do not always receive the same financial support, or are not aware how to access it when it exists.

8.5 Implications for future employment and skills

> *"The nature of the skills we need is also evolving. The needs of growing markets like bioscience and low-carbon will require new and higher level skills. The skills system needs to equip Britain with a workforce capable of prospering in the demanding conditions of a globalised knowledge economy." (National Skills Strategy, 2009)*

We have already noted that low carbon is one of six priority sectors identified in New Industries, New Jobs (BERR, 2009). This strategy document highlights the need for a forward looking approach to forecasting and planning new skills needs in low carbon as well as the importance of Government intervention to stimulate demand.

> *"We require a skills system that not only responds to demand but is also able to anticipate future growth in the economy in areas such as low carbon or bioscience… For example, when the Government regulates standards in… low carbon requirements for building construction it has a direct impact on the demand for, and investment in, skills and certain technologies. Indeed, the very success of the Government's wider policies may depend on its ability to equip or incentivise businesses and their employees in Britain to implement them." (BERR, 2009)*

This document also heralded the publication of the Low Carbon Industrial Strategy, also in 2009, which sets out in more detail the Government's view of the key actions required to help businesses meet the challenges of growing the low carbon sector in general. It recognises, however, that there is a need to 'green' jobs across all sectors if its economic and social targets are to be achieved. This view has been echoed by many of the industry stakeholders that participated in this study.

> *"Equipping Britain to take advantage of the move to low carbon is a social obligation as well as an economic imperative. It requires policies that enable people to respond to industrial change positively, through the acquisition of new skills and access to new opportunities and new jobs. The economic opportunities and threats arising from the shift to low carbon extend across the entire British economy. Effectively, every job will need to be a 'green' job." (BIS & DECC, 2009)*

The Low Carbon Industrial Strategy cites work already undertaken by a Strategic Advisory Group of employers in the wider low carbon sectors which identified two main sets of future skills requirements for the sector. The first of these relates, as we have previously noted, to the supply of suitably qualified employees in STEM subjects, which are described as particularly acute in the low carbon sector. The second set of skills relate to more general skills such as leadership and management as well as sustainable procurement, environmental management systems, risk management, monitoring and measuring.

The Strategy also highlights that, to date, employers have not yet been very vocal in expressing the demand for low carbon skills and that, as a result, there has been a limited supply side response. This issue has also been raised by participants in this research, particularly by Sector Skills Councils, which have described the current situation as 'chicken and egg': employers are unlikely to express a demand for training if the provision is limited and providers are equally unlikely to offer the necessary training if there is no strong evidence of demand.

> *"A Review of Evidence commissioned by Defra [in 2009] concluded that there was latent demand for low carbon skills, but that this was not being articulated by employers and, as a result, the skills system was ill-equipped to respond." (BIS & DECC, 2009)*

This document also notes the fragmented evidence base in relation to low carbon skills needs and the difficulties involved in forecasting accurately potential growth and future skills needs. It therefore states that a much more 'activist' role is required on the part of the Government but that employers, HE and FE also have a crucial role to play. It sets out a number of key actions to help achieve this, including:

- Addressing the labour market information gap;
- Requesting the UK Commission to produce an annual National Skills Assessment of priority industries;
- Refocusing funding on priority areas, both in terms of skills provision and research and development in HE institutions;
- Leveraging public procurement to embed skills requirements;
- Better information and careers guidance in relation to the needs of the low carbon industry; and
- Brokering 'coalitions' of leading employers and representatives from higher and further education.

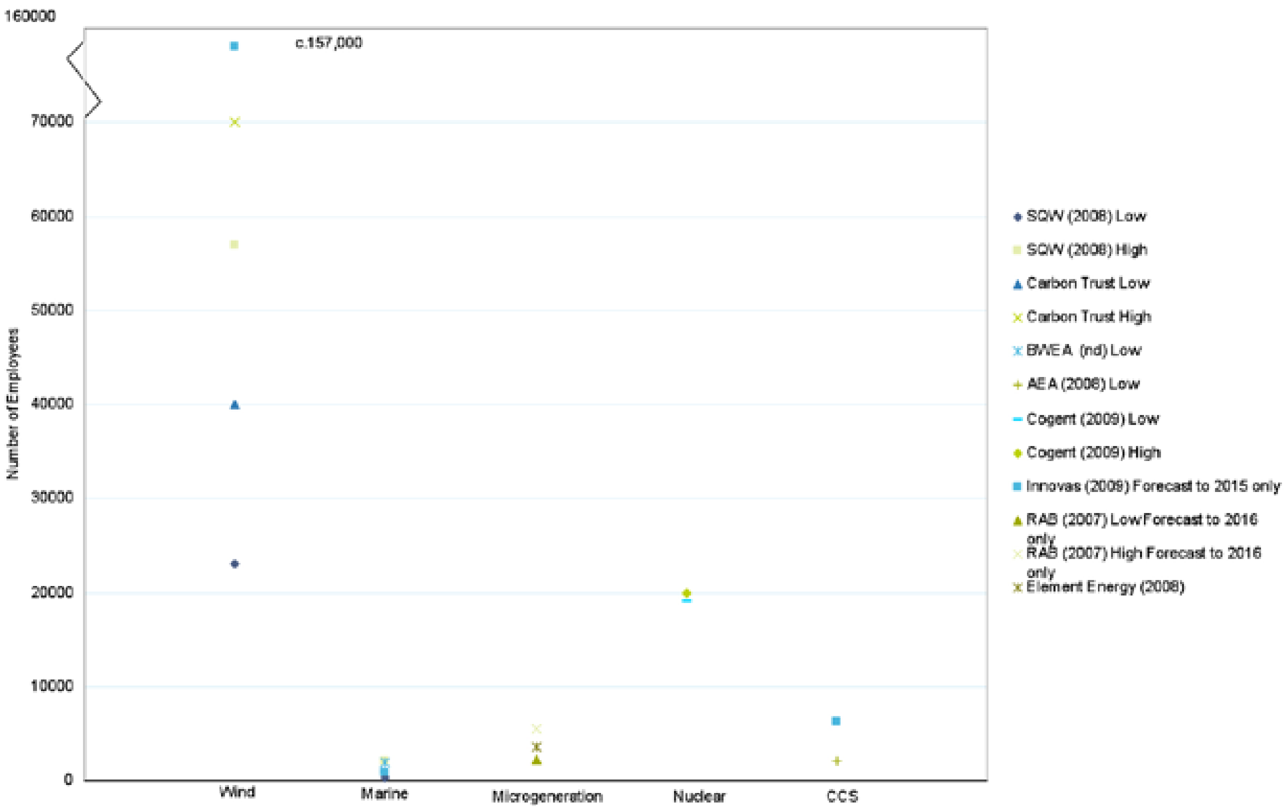
The Government has therefore made a clear commitment to driving forward the skills agenda in the low carbon sector. It is clear from our research that such an active approach will be required to achieve the necessary growth in the low carbon energy generation sector.

Indeed, as the recently published National Skills Strategy states, a Sector Skills Accord between employers, sector bodies and awarding bodies (led by the British Wind Energy Association as part of the renewable energy strategy) was signed in October 2009. This Accord includes employer commitments such as resources to develop industry specific National Occupational Standards and qualifications, new apprenticeship frameworks, career pathways and enhanced STEM guidance.

8.5.1 Future employment growth in low carbon energy generation

There is general agreement across the sector that low carbon has considerable potential to generate employment growth, which could help to balance out a decline in employment within more traditional energy generation. However, the scale of the future employment within the sector will be heavily influenced by the response of both the Government and industry to the key drivers and barriers set out earlier in this chapter and to the implementation of the policies set out above. As shown in Figure 39, projections of future employment vary considerably depending on the source and assumptions made and forecasting future employment is not made any easier by the lack of current official national statistics on current employment in the sector.

Figure 39: Future employment projections to 2020 by source



Source: PwC analysis of AEA (2008) Future Value of Coal Carbon Abatement Technologies to UK Industry, BWEA (2009) Marine Renewable Energy: State of the Industry Report, Carbon Trust (2009) Focus for success: a new approach to commercialising low carbon technologies, Cogent (2009) Power People: The Civil Nuclear Industry 2009-2025, Element Energy (2008) The Growth Potential for Microgeneration in England, Wales and Scotland, Innovas (2009) Low Carbon and Environmental Goods and Services: an industry analysis, RAB (2007) The role of on-site energy generation in delivering zero carbon homes & SQW (2008) Skills and employment in the wind, wave and tidal sectors.
Note: Estimates of future employment by Innovas include both direct and indirect employment to 2015

Regardless of the scale of the future employment, there are four key issues which the UK will need to address to ensure that a suitably skilled workforce is in place to meet future employment needs of the sector. These are as follows:

- Competition for STEM students: as discussed in the preceding chapter the ability to attract STEM students at all levels (i.e. from apprentices to post graduates), amidst growing demand for such skills across industry as a whole, will influence the sector's ability to develop and maintain a highly skilled workforce;

- An ageing workforce: as older and more senior members of the current workforce begin to retire it will be imperative for the sector to recruit and train new entrants over the next decade so that they have the skills and experience required to replace retirement-related attrition;

- Technology transfer skills: the sector's ability to commercially exploit the UK's lead in the research and development of technologies such as marine, CCS and to a lesser extent off-shore wind will depend on effective engagement of technology transfer skills/roles; and

- Strength of the value chain: this will be influenced by Government support and the level of private sector engagement. However, a well embedded value chain will maximise the potential for job creation within the sector and also require a wider range of skill sets, in relation to manufacturing jobs as well as higher level planning and development jobs.

8.6 Suggestions for future skills provision

According to a recent report published by Department for Employment and Learning in Northern Ireland, the demand for STEM subjects to NQF Level 4 and above will rise from a third of education leavers to a half by 2020, whilst the supply of physical science related skills in particular – such as physical science, mathematical sciences, computer science, engineering and technology, and architecture, building and planning – will decline by more than a quarter during this time.[231] The report makes the following recommendations to address the shortage of supply: [232]

- Businesses must take the lead in promoting STEM subjects;

- Key constraints in the STEM artery should be alleviated;

- There needs to be increased flexibility in the provision of STEM education; and

- The Government must co-ordinate its support of STEM provision.

[231] Department for Employment and Learning (2009) Report of the STEM Review

[232] Department for Employment and Learning (2009) Report of the STEM Review, p.119

The view that the sector itself has a key role to play in terms of engaging education providers and encouraging the uptake of STEM subjects is supported by the Council for Industry and Higher Education's STEM Review.[233] There needs to be strong focus on the UK's capacity to train and/or retrain workers for employment in the sector. Appropri¬ate courses will have to be provided, which are accessible to new entrants as well as those already in employment who need to re-skill (e.g. civil engineers who have been employed in the off-shore gas industry and wish to make the transition to off-shore wind farms). However, such capacity will require significant investment:

> *"Given the need for expensive equipment such as practice towers and nacelles, wave tanks to replicate off-shore conditions and the like, set¬ting up a training centre will require millions of pounds. One proposal for a comprehensive centre located alongside NaREC in Blyth has been costed at £27m. Training effort needs to be focused in perhaps seven or eight centres that will need this kind of significant funding. As with manufacturing and construction ports for off-shore, Government needs to plan strategically and fund a limited number of facilities. Re¬sources will have to be found to train the train¬ers, in a new sector where those with knowl¬edge and experience are needed to actually build and operate the generation capacity."* [234]

To summarise, the overall skills needs of the sector relate mainly to the supply of a suitably qualified workforce in STEM subjects, with the development of softer skills such as leadership and management and technology transfer skills also becoming increasingly important.

> *"The UK has traditionally been strong in [low carbon] R&D. There will possibly be opportunities in construction and installation and operations and maintenance. We will need to increase technical training for construction and installation and operations and maintenance as this is often done in a rather haphazard manner." (Head of HR, Carbon Trust)*

> *"In 2020 increased automation [of manufacturing for low carbon energy generation technologies] and the drive for improved process/product efficiency will result in a need for more high-level skills, such as materials engineering. There will also be demand for leadership and management skills and process and technical expertise, which will lead to innovation." (ProSkills)*

[233] CIHE (2007) STEM Review the Science Technology Engineering and Maths Supply Chain
[234] BWEA (2009) Powering the Green Economy

9 Three possible futures for the low carbon energy sector

Chapter summary

This section of the report presents three potential future scenarios for the low carbon energy generation sector. These scenarios are based on our analysis of the findings from our desk research and interviews with industry stakeholders and, in particular, the discussion of the drivers for change and the barriers to growth in the previous chapter. These scenarios are intended to be illustrative only and are therefore schematic in nature. Much will obviously depend on the state of the economy and progress in carbon markets in 2020.

It is clear that governance (by which we mean both Government support and regulation) will be one of the key forces in the development of the industry to 2020. Coupled with this, will be the impact of innovation in the sector (a broad term, encompassing not only technological developments, but also private sector responsiveness to the opportunities on offer and the emergence of new ways of working to exploit the UK's strengths in research and development).

Using these two key drivers, we have developed our scenarios based on a future which holds 1) low governance, low innovation; 2) high governance, low innovation; and finally 3) high governance, high innovation.

The high innovation, low governance scenario is not considered in this analysis, as our research suggests, it is very unlikely that the UK will achieve a competitive position in the new technology markets without sufficient stimulus from the Government. Given the high policy priority given to the low carbon sector, and, indeed the Government's legally binding targets to reduce carbon emissions by around a third by 2020, we would suggest that this scenario is not, therefore, likely to be relevant or applicable in 2020.

In Scenario 1, significant barriers remain to the rollout of low carbon technologies due to financial and other constraints. The UK's existing energy generation technologies maintain approximately the same proportion of the overall market share as in 2009, with an increase in overall capacity in order to meet growth in the demand for energy. Renewables, therefore, maintain a minimal share of total energy generation capacity in comparison to fossil fuels. In this scenario, slow growth in the deployment of the low carbon technologies covered in this report may lead to increased adoption of other renewables technologies, including biomass, however this growth would be constrained by low levels of governance.

In Scenario 2, there is moderate growth in the wind sector as a whole, driven by some off-shore development, however the 2020 targets are not met. The development of CCS and marine technologies loses momentum; only two of the planned nuclear units become operational by 2020; and Microgeneration installations increase as a result of the Feed in Tariff and Renewable Heat Incentive, but overall growth is moderate.

In Scenario 3, the UK maintains a strong position in CCS and marine technologies and becomes the largest market globally for off-shore wind. The significant size of the UK renewables market acts as a further driver for investment in the UK. CCS and marine technologies may not yet be deployed on a large scale, but the UK has a strong role in research, demonstration and testing and is developing the necessary value chain to benefit from rollout in the coming years. Microgeneration technologies are installed on a significant share of buildings (new and retrofit). There is zero slippage in the timescales for new build nuclear and three units are operational by 2020.

This section also elaborates the likely employment and skills implications under each of these scenarios. It explores the impact of each scenario on likely employment figures in the industry as a whole and for each sub-sector and considers the potential skills needs for each sub-sector under study, i.e. wind, marine, carbon capture and storage; nuclear and microgeneration.

9.1 Introduction

This chapter of our report considers the potential for growth in the low carbon sector under three different possible future scenarios and the likely consequences for employment and skills. It is structured as follows:

- The low carbon scenario analytical framework;
- Scenario 1: low governance, low innovation;
- Scenario 2: high governance, low innovation;
- Scenario 3: high governance, high innovation; and
- Overall implications for employment and skills in 2020.

9.2 The low carbon scenario analytical framework

We have argued in the previous section that, growth in the low carbon sector will require the Government to continue with demand-side and supply-side levers to encourage private sector investment. The scale and quality of private sector investment and the attractiveness of the resulting technological solutions and business models will also determine the rate of growth of the industry. Therefore, having considered a number of drivers impacting both the UK and global low carbon energy generation markets, the two drivers which our analysis and interviews suggest are most valid are governance and innovation. These drivers are not mutually exclusive, but their importance to the future for low carbon energy generation was a common theme emerging from both our desk-based research and stakeholder interviews. Our definitions of these two key drivers are considered in greater detail below.

The key levers within governance fall into two categories, as follows:

- **Growing the UK low carbon energy market:** through legislation; tariff support; direct funding; improving the infrastructure and facilitating investment, for example; and
- **Developing the UK value chain:** through, for example, providing tax incentives; and investing in skills and training.

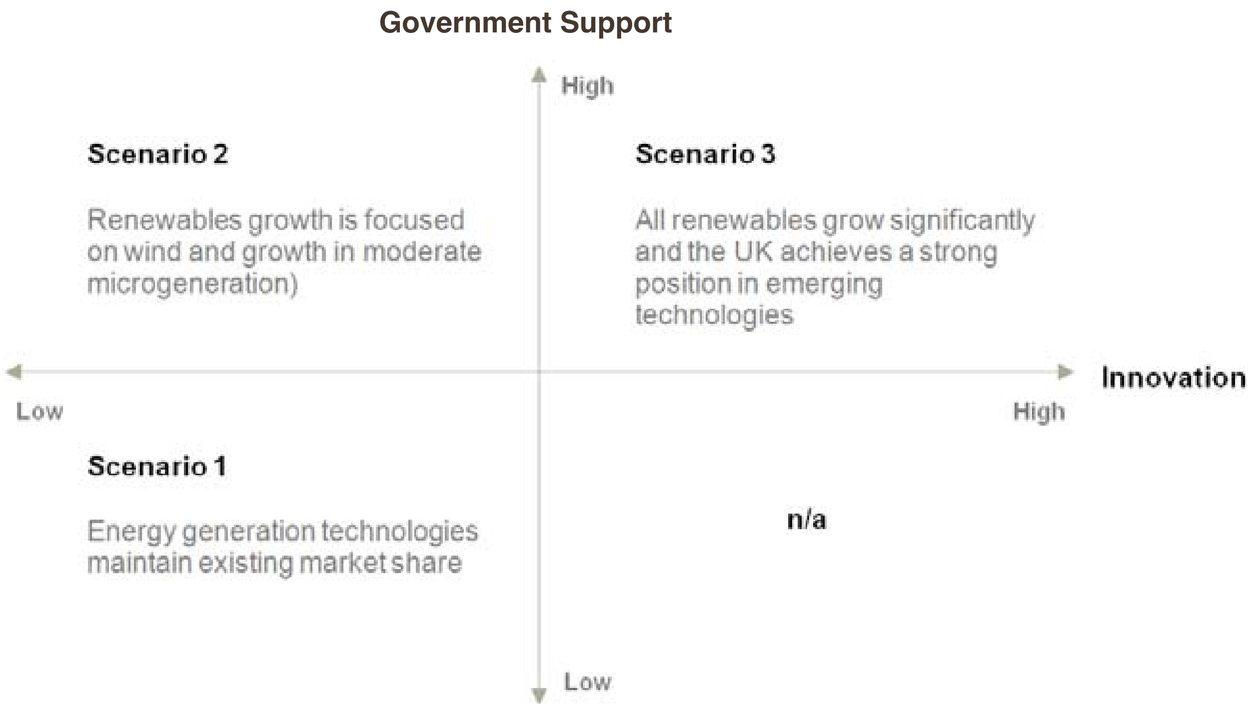
The key levers included within innovation include:

- **Technological breakthroughs:** through, for example the commercialisation of carbon capture and storage and marine technologies and the scale of future deployment of off-shore wind turbines;
- **Private sector responsiveness:** for example, the appetite within the industry to respond to, and indeed stimulate, the economic and technical feasibility of new technologies; and
- **New ways of working:** through for example, increased collaboration between industry and universities to facilitate technology transfer.

Using these two dimensions we have identified the three scenarios illustrated in Figure 40. On our scale of low to high:

- **Low governance** means that the Government does not actively support the sector through legislation, tariff support or funding nor does it encourage investment in the UK value chain;
- **High governance** means that the Government actively supports the sector via all of the means above and also encourages investment in the value chain;
- **Low innovation** means that there is a lack of innovation and private sector engagement in the industry;
- **High innovation** means that the UK maintains and enhances its market leading position in emerging technologies, the private sector responds rapidly to the opportunities on offer, and new collaborative ways of working come to the fore.

Figure 40: Low Carbon Energy Generation Scenarios



Source: PwC analysis of stakeholder interviews and desk based review of secondary data sources. For a full list of the data sources used see Annex F.

The high innovation, low governance scenario is not considered in this analysis, as our research suggests, it is very unlikely that the UK will achieve a competitive position in the new technology markets without sufficient stimulus from the Government. Given the high policy priority given to the low carbon sector, and, indeed the Government's legally binding targets to reduce carbon emissions by around a third by 2020, we would suggest that this scenario is not, therefore, likely to be relevant or applicable in 2020.

While there are evidently any number of possible scenarios, or variations thereof, in relation to the future of the low carbon energy sector, we are confident that the three scenarios selected represent feasible descriptions of the sector ten years from now; this issue is discussed further in Annex D of this report. It should be noted, however, that these scenarios present possible, rather than likely high-level scenarios, and are dependent on a range of factors, including the state of the economy and energy and carbon markets. The actual outcome may well be more nuanced, with some sub-sectors moving ahead more rapidly, others facing delays.

Our employment projections include construction and installation jobs and are based on an estimation of the FTE required per GW of output produced. One assumption which underpins all three scenarios is that the productivity of the low carbon industry remains constant over the next decade. This assumption is backed up by our stakeholder interviews and desk based research, which suggest that there is unlikely to be a paradigm shift within low carbon energy generation. The tenets underpinning the three selected scenarios have also been tested and validated by industry experts. [235]

9.3 Scenario 1: Low Governance, Low Innovation

In Scenario 1, significant barriers remain to the rollout of low carbon technologies due to financial and other constraints. The UK's existing energy generation technologies maintain approximately the same proportion of the overall market share as in 2009, with an increase in overall capacity in order to meet growth in the demand for energy. Renewables, therefore, maintain a minimal share of total energy generation capacity in comparison to fossil fuels. Under this scenario, slow growth in the deployment of the low carbon technologies covered in this report may lead to increased adoption of other renewables technologies, including biomass, however this growth would be constrained by low levels of governance. Table 20 details the likely implications of Scenario 1 for the low carbon workforce by sub-sector in 2020.

[235] Please note that, as we have stated previously, with the exception of the nuclear sub-sector, low carbon energy generation is an industry that is at an early stage in its development, so much so that there is currently no comprehensive monitoring information on the industry's workforce statistics. The workforce data presented in these scenarios is therefore based on best guess estimates which have been validated by industry experts.

Table 20: Scenario 1: Implications for the low carbon workforce in 2020

Scenario 1: low governance, low innovation

Sub-sector	Description	2020 Energy Generation (GW)	Direct employment in 2009(2)	Direct employment in 2020(2)
Wind	On-shore wind remains the dominant form of renewable energy in the UK Manufacture continues to happen outside the UK Lack of improvement to the UK port infrastructure restricts overall growth in off-shore wind The third round of the Crown Estate's off-shore programme receives reduced interest	**15**	**4,000**	**15,000**
Marine	Lack of innovation means that no marine/tidal technologies are nearing commercialisation by 2020 Private sector investment is reduced due to increasing uncertainty of future returns	**0**	**500**	**400**
CCS	A decline in private sector engagement and existing companies withdraw from the CCS competition The UK does not have a strong position in the research of this technology relative to other countries Technology reaches commercialisation by 2020, with implications for the UK value chain	**0**	**0**	**0**
Nuclear	One of the four nuclear units currently planned becomes available by 2020 Companies do not actively invest in the UK market, circa 30% of the value chain is supplied by businesses within the UK	**5**	**24,000**	**15,900**
Microgeneration(1)	The Government remains focused on installing microgeneration technologies in new builds so the market for large scale retrofitting does not take off	**0.5**	**1,000**	**1,000**
Total		**20.5**	**29,500**	**32,300**

Source: PwC analysis of stakeholder interviews and desk based review of secondary data sources. For a full list of the data sources used see Annex F.
Note: (1) Our figure for microgeneration employment is an estimate of the total new job creation as a result of engagement in the design, manufacture, installation and maintenance of microgeneration technologies. The total FTE engaged in installation and maintenance activities is likely to be larger. However, this has been excluded from Table 20 as it represents a change in the activities undertaken by those already employed within the building services engineering sector rather than new job creation.
Note: (2)Overall employment includes employment in construction and installation of low carbon energy generation infrastructure.

9.3.1 Implications for employment and skills

The additional 6GW of energy produced under this scenario alone is insufficient to meet the estimated growth in demand for energy (i.e. from 88GW in 2009 to 104GW in 2020).[236] Therefore an increase in the level of output and thus employment in carbon rich energy generation is required to meet the increased demand.

In 2009, around 50,000 jobs [237] were involved in the production and distribution of around 70GW of energy from fossil fuels. If energy output from these sources were to increase to 80GW (or 115 per cent of 2009 output) as outlined in the above scenario then employment might be expected to rise to around 57,000, assuming that the ratio of jobs to unit output remains constant.[238] Under this scenario, therefore, total employment in UK energy generation could be expected to increase from around 80,000 in 2009 to c.89,000 in 2020 (including 32,300 low carbon jobs). Nuclear energy remains a key employer within the low carbon energy sector, but is almost matched by employment in wind. Employment in marine and CCS remains relatively small scale (i.e. around 1 per cent). The paragraphs which follow provide greater detail on the specific implications of Scenario 1 for employment and skills in each of the low carbon sub-sectors under study.

9.3.1.1 Wind

In this scenario, on-shore wind continues to represent the majority of employment in wind energy with slow growth in the off-shore market. Overall employment increases to c.15,000. A significant share of the manufacturing is still done outside of the UK, but opportunities for UK businesses exist in the installation, operations and maintenance and design segments of the value chain as shown in Table 21.

The greatest increase in demand, created by this rise in employment, will be for highly qualified STEM students, (e.g. engineers with a degree or postgraduate qualification). However, some increase in demand will be expected across all job roles and skills levels (e.g. wind turbine technicians). The significant growth in employment over such a short time period will also exacerbate the existing skills shortages and gaps outlined in the Insight section of this report.

Section 3.4 of this report included a vignette describing the role of a Wind Turbine Engineer in 2009. The following vignette describes what we might expect this Turbine Engineer to be doing in 2020.

[236] HM Government (2009) The UK Renewable Energy Strategy, London: BIS and DECC

[237] i.e. 80,000 jobs in production and distribution of electricity & gas minus the 30,000 employed within low carbon energy generation (Source: ONS (2009) in UK Employment and Skills Almanac 2009 and PwC analysis)

[238] i.e. 714 jobs per GW output.

Where are they in 2020?

Our Turbine Engineer continues to work for RES and was recently promoted to Project Development Engineer due to his years of experience as a Turbine Engineer. His new role involves working with the Business Development Team and supporting ongoing project development. Jamie is in charge of a team of Turbine Engineers. The job they are doing today is not a whole lot different from what was being done back in 2009.

Source: Subject from RES website. (Available at: http://www.res-group.com/careers/meet-our-people.aspx, last accessed 26th November 2009). Story is PwC's own creation.

9.3.1.2 Marine

Employment within the marine sector remains concentrated in the research phase of the value chain. A reduction in private sector investment leads to a slight decrease in overall employment (i.e. from 500 in 2009 to 400 in 2020). Furthermore, other phases of the value chain, such as manufacturing do not take off in the UK, which reduces the potential for growth in supply chain jobs.

9.3.1.3 Carbon Capture and Storage (CCS)

The UK loses its position in CCS research, employment in CCS technologies remains negligible and the potential for exporting UK expertise in the future is significantly reduced.

9.3.1.4 Nuclear

We have assumed that, due to the expected lifetime of the UK's existing nuclear sites, only three of the ten nuclear sites which are currently active within the UK will still be online in 2020. Our view of the future of the UK nuclear energy generation industry in Scenarios 1-3 is broadly similar to Cogent's first scenario within their Power People report.[239] Cogent's scenario assumes that, a further four new units (configured as two twinned units) are expected to become available from 2017 to 2025.

Our rationale for adopting Cogent's first scenario is based on interviews with key stakeholders who suggested that the construction of new builds is likely to happen in 18 month intervals: the resulting capacity figures from these new builds appear more in line with the Government's strategy than those in Cogent's alternative scenario.

In this scenario, project timeframes are extended and only one nuclear new build becomes available by 2020. In the medium term, reducing the total number of active nuclear sites from ten to four will lead to a decrease in nuclear employment from 24,000 to 15,900, driven mainly by lower levels of employment within electricity generation and fuel processing roles (which will decline to c.2,450 and c.2,000 respectively – or 33 per cent and 44 per cent of the 2009 employment in these areas). There will also be a reduction in the number of decommissioning jobs, although this will be to a lesser

[239] Cogent (2009) Power People: The Civil Nuclear Industry 2009-2025

degree (i.e. to c.11,400 or 95 per cent of the 2009 employment). The duration of this downturn will be heavily dependent on the timescales for future new builds.

The localised nature of key elements of the nuclear value chain mean the new build programme results in planning, construction and operational jobs within the UK supply chain. However, insufficient investment and up-skilling by UK businesses means the majority of component manufacture takes place outside of the UK and an immigrant workforce is required, especially for the higher value engineering elements of the value chain related to nuclear infrastructure. Despite this decline in overall employment, Cogent suggest that 70 per cent of the current workforce will retire by 2025, creating potential skills gaps in terms of experienced managerial roles.

9.3.1.5 Microgeneration

Growth in the overall FTE engaged in microgeneration activity is negligible. The design, installation and maintenance of microgeneration systems continue to be undertaken by the building services engineering sector (i.e. plumbers and electricians). To avoid a skills gap in terms of systems design, integration and/or health and safety knowledge, increased training provision will be required to cope with future growth in the demand for trained installers.

9.4 Scenario 2: high governance, low innovation

In this scenario, there is moderate growth in the wind sector as a whole, driven by some off-shore development, however the 2020 targets are not met. The UK loses its market leading position in marine technologies and loses its relatively strong position in CCS; only two of the planned nuclear units become operational by 2020; and microgeneration installations increase as a result of the Feed in Tariff and Renewable Heat Incentive, but overall growth is moderate. Table 21 presents the implications for the UK low carbon workforce in 2020 under Scenario 2.

Table 21: Scenario 2: Implications for the low carbon workforce in 2020

Scenario 2: high governance, low innovation

Sub-sector	Description	2020 Energy Generation (GW)	Direct employment in 2009[2]	Direct employment in 2020[2]
Wind	Wind remains the dominant form of renewable energy in the UK The UK becomes the largest global off-shore market, but a lack of private sector engagement limits the improvements in the UK port infrastructure, constraining growth and resulting in a significant amount of the value chain being imported	**20**	**4,000**	**23,000**
Marine	Despite high levels of Governance a lack of private sector engagement means a limited number marine and tidal technologies are deployed by 2020	**0.5**	**500**	**1,000**
CCS	The UK does not have a strong position in the research of this technology relative to other countries and no technology reaches commercialisation by 2020 The UK Government begin to promote the UK as a future location for storing CO2 from other countries.	**0.8**	**0**	**1,000**
Nuclear	Two nuclear new builds become available The strong uptake of wind technology means no additional nuclear capacity is planned Companies do not actively invest in the UK market, c.30% of the value chain is supplied by businesses within the UK	**7**	**24,000**	**16,400**
Microgeneration[1]	Strong uptake of microgeneration (similar to levels in Germany) Significant growth in uptake of CHP (particularly in non-domestic settings) New legislation encourages retrofit in existing housing stocks and non-domestic buildings, but long payback periods constrain uptake Smart grids make it easier to feed electricity back into the grid	**3.5**	**1,000**	**5,500**
Total		**32**	**29,500**	**46,900**

Source: PwC analysis of stakeholder interviews and desk based review of secondary data sources. For a full list of the data sources used see Annex F.
Note: (1) Our figure for microgeneration employment is an estimate of the total new job creation as a result of engagement in the design, manufacture, installation and maintenance of microgeneration technologies. The total FTE engaged in installation and maintenance activities is likely to be larger. However, this has been excluded from Table 21 as it represents a change in the activities undertaken by those already employed within the building services engineering sector rather than new job creation.
Note: (2) Overall employment includes employment in construction and installation of low carbon energy generation infrastructure.

9.4.1 Impact on employment and skills

In order to meet the increased demand for energy, the level of output and therefore the level of employment in carbon rich energy generation remains constant at around 70GW and 50,000 jobs.[240] Therefore total employment in UK energy generation is expected to rise from around 80,000 in 2009 to c.97000 in 2020 under this scenario (including 46,900 low carbon jobs). However, it should be noted that much of this employment growth will involve the construction and installation of significant developments to the low carbon infrastructure (particularly for off-shore wind) and therefore may be relatively short-term. To put this into perspective, construction and installation jobs are likely to make up approximately a third of employment in wind and marine (i.e. around 7,500). The paragraphs which follow provide greater detail on the specific implications of Scenario 2 for employment and skills in each of the low carbon sub-sectors under study.

9.4.1.1 Wind

In this scenario, wind becomes the dominant employer in low carbon energy rising rapidly from 4,000 in 2009 to 23,000 in 2020. However, UK businesses fail to fully engage in the sector and a significant proportion of the wind turbines deployed in the UK are imported. In this future case, the current wind value chain in the UK is effectively scaled up, with UK companies involved in some elements of component manufacture, as well as installation, operations and maintenance and design of wind farms. This growth is expected to increase the demand for high level STEM qualifications and exacerbate existing skills shortages and gaps even further.

9.4.1.2 Marine

In this future case scenario, there is marginal growth in marine employment from 500 to 1,000 as one or more wave/tidal technologies are proven on a commercial scale. However, the lower than expected return on investment due to higher costs incurred in the research phase means deployment does not meet the Government's projections by 2020. Furthermore, lack of private sector investment in UK manufacturing capacity results in a large share of manufacture being outsourced to low-cost countries. Research roles still dominate marine employment, but planning, installation and servicing jobs are beginning to emerge as well as indirect employment in component manufacture. However as low-cost countries establish themselves as the market leaders in the manufacturer of marine technologies, the UK may find it increasingly difficult to compete in this area. A similar pattern has already been observed in the UK value chain for on-shore wind energy generation.

9.4.1.3 Carbon Capture and Storage (CCS)

In this scenario, the UK loses its strong international position in CCS development. However, the early stage of the product life-cycle means that this primarily leads to a reduction in research investment. There is no significant impact on the UK value chain and the 1,000 new jobs created within this sub-sector are mainly in research and development.

[240] i.e. 80,000 jobs in production and distribution of electricity and gas minus the 30,000 employed within low carbon energy generation (Source: ONS (2009) in UK Employment and Skills Almanac 2009 and PwC analysis)

In the longer term, there is still potential for growth in the UK industry because the availability of UK CO2 storage sites and the local nature of transport networks. There is therefore scope for a larger UK value chain in the future, creating the potential for significant growth in future employment across all aspects of the value chain beyond 2020.

9.4.1.4 Nuclear

In this scenario, a high level of Governance means that two new builds become available by 2020 (configured as a twinned unit), although the UK's total nuclear energy generation capacity still falls short of the Government's plan for 2020. However, lack of engagement by UK businesses results in a significant share of the value chain being imported. Again, in the medium term, reducing the total number of active nuclear sites will lead to a decrease in employment, with electricity generation and fuel processing roles declining to c.2,950 and c.2,000 respectively – or 40 per cent and 44 per cent of the 2009 employment. Again there will be a reduction in the number of decommissioning jobs, although this will be to a lesser degree (i.e. to c.11,400 or 95 per cent of the 2009 employment). Retirement-related attrition is likely to create significant skills gaps despite the decrease in overall employment.

In Section 6.4 of this report there is a vignette describing the role of a Nuclear Reactor Operator in 2009. The following vignette describes what we might expect this him to be doing in 2020.

Where are they in 2020?

Our Reactor Operator is still working for British Energy in Sizewell B, but his years of experience in the nuclear industry have earned him a promotion to Engineering Safety Manager. Typical day to day operations include evaluating engineering designs, options studies, safety case preparation and analysis, safety management appraisals and implementation of six sigma safety initiatives.

The closure of a number of nuclear power stations in the UK means that many of his colleagues who were previously engaged in energy generation activities at these sites are now working in decommissioning or the nuclear defence industry. Although most will return to energy generation as the new sites proposed in the nuclear new build programme come online towards 2020.

Source: Subject from British Energy website. (Available at: http://www.british-energy.com/pagetemplate.php?pid=302#3, last accessed 24th November 2009). Story is PwC's own creation.

9.4.1.5 Microgeneration

Whilst high levels of Governance may encourage microgeneration deployment (potentially increasing engagement to 5,500 FTE), a skills gap will emerge in terms of the number of trained and/or certified operatives, unless action is taken to increase the supply of training. This will create a bottleneck in the design and installation segment of the value chain and thus constrain growth.

9.5 Scenario 3: high governance, high innovation

In this scenario, the UK has a leading position in CCS and marine technologies and becomes the largest market globally for off-shore wind. The significant size of the UK renewables market acts as a further driver for investment in the UK. CCS and Marine technologies may not yet be deployed on a large scale, but the UK has a strong role in research, demonstration and testing and is developing the necessary value chain to benefit from rollout in the coming years. Microgeneration technologies are installed on a significant share of buildings (new and retrofit). There is zero slippage in the timescales for new build nuclear and three units are operational by 2020.

Table 22 presents the implications for the UK low carbon workforce in 2020 under Scenario 3.

Table 22: Scenario 3: Implications for the low carbon workforce in 2020

Scenario 3: high governance, high innovation

Technology	Description	2020 Energy Generation (GW)	Direct employment in 2009[2]	Direct employment in 2020[2]
Wind	Wind remains the dominant form of renewable energy in the UK. Off-shore wind develops rapidly and the UK becomes the largest global off-shore market. The UK port infrastructure is improved, encouraging manufacturers to invest and locate in the UK to produce for the UK market. Globally most turbine manufacture remains in low cost countries and existing locations. The UK value chain supplies c.60% of UK needs and at least one turbine manufacturer locates in the UK.	**27**	**4,000**	**40,000**
Marine	1GW of marine technology is deployed. The UK value chain is developing across all aspects (although some of the manufacturing may still take place in low cost countries). The export market is also generating revenue and employment for UK companies.	**1**	**500**	**2,000**
CCS	Three 400MW demonstrator plants are in operation and two 1,600MW plants have 400MW of CCS capacity each. UK businesses are well positioned to develop strong propositions across the value chain. The UK Government begin to promote the UK as location for storing CO2 from other countries.	**2**	**0**	**2,000**
Nuclear	Three of the four nuclear units become available. C.70% plus of the supply chain is UK-based.	**8**	**24,000**	**17,000**
Microgeneration[1]	Significant uptake in new houses. New legislation encourages uptake in existing housing stocks and non-domestic buildings. Smart grids make it easier for UK households to feed electricity back into the grid. The technology becomes more cost-effective.	**7**	**1,000**	**9,500**
Total		**45**	**29,500**	**70,500**

Source: PwC analysis of stakeholder interviews and desk based review of secondary data sources. For a full list of the data sources used see Annex F.
Note: (1) Our figure for microgeneration employment is an estimate of the total new job creation as a result of engagement in the design, manufacture, installation and maintenance of microgeneration technologies. The total FTE engaged in installation and maintenance activities is likely to be larger. However, this has been excluded from Table 22 as it represents a change in the activities undertaken by those already employed within the building services engineering sector rather than new job creation.
Note: (2) Overall employment includes employment in construction and installation of low carbon energy generation infrastructure.

9.5.1 Impact on employment and skills

Under this scenario, the increase in the capacity is enough to cover the estimated increase in demand for energy and allow for a reduction in carbon rich energy generation. The significant increase in low carbon employment (which has more than doubled since 2009) is therefore likely to be offset by a declining employment in carbon rich energy generation sectors. If energy output from these sources were to decline from 70GW to 53GW (or around half of total output in 2020) then employment might be expected to decline from c.50,000 jobs[241] to around 40,000 (assuming that the ratio of jobs to unit output remains constant).[242] Under this scenario, the overall impact on employment in UK energy generation would be an increase from around 80,000 in 2009 to c.111,000 in 2020 (including 70,500 low carbon jobs), thus creating the creating the potential for skills transfer. The construction and installation skills required in off-shore oil and gas industry could, for example, be applied to off-shore wind farms and knowledge of depleted oil wells could be used in site characterisation for the storage of CO2.

A further point to note is that, as in Scenario 2, this scenario will involve significant developments to the low carbon infrastructure, which will generate employment in short- to medium-term activities such as construction and installation. To put this into perspective, construction and installation jobs are likely to make up approximately 19,000 of employment in 2020 (i.e. around 26 per cent in 2020, compared to just 7 per cent in 2009). Employment growth across the UK energy sector as a whole is therefore reduced and the issue is more one of re-skilling the existing workforce than creating a new low carbon workforce. The paragraphs which follow provide greater detail on the specific implications of Scenario 3 for employment and skills in each of the low carbon sub-sectors under study.

9.5.1.1 Wind

The considerable growth in both on-shore and off-shore wind, under this Scenario, accounts for around two thirds of employment in low carbon energy. All aspects of the value chain are strengthened from research through to manufacture, installation, operations and servicing. The decision to locate a turbine manufacturing plant in the UK will create c.1,000 new jobs (with an 80:20 split of manufacturing and R&D jobs). [243]

There are also opportunities for component manufacture, leaving the UK well-positioned to take advantage of future opportunities created by growth in global wind deployment.

Under this Scenario, demand for manufacturing skills will increase within the UK as will the demand for high level STEM qualifications and existing skills shortages will be exacerbated even further.

[241] i.e. 80,000 jobs in production and distribution of electricity & gas minus the 30,000 employed within low carbon energy generation (Source: ONS (2009) in UK Employment and Skills Almanac 2009 and PwC analysis)

[242] i.e. 714 jobs per GW output.

[243] We have assumed that due to the increase in the UK's market position this new plant will be on a larger scale than the former Vestas plant which employed approximately 700 people, 150 in R&D and 550 in manufacturing. (source: The Guardian, see: http://www.guardian.co.uk/business/2009/apr/28/vestas-wind-turbine-factory-close)

9.5.1.2 Marine

The UK becomes the global centre of marine research and businesses build on this position to embed all aspects of the value chain and establish manufacturing capacity within the UK. While some of the lower value components may be outsourced to low cost countries, a significant proportion of the value chain remains in the UK and businesses are well-positioned to take advantage of an increased global demand for the technology. This leads to an increase in employment from around 500 in 2009 to 2,000 by 2020. These jobs are mainly in research, but demand for manufacturing jobs is emerging and there is the potential for significant growth in employment across all aspects of the value chain beyond 2020.

9.5.1.3 Carbon Capture and Storage (CCS)

Even in the best case, the CCS market is still likely to be in the early stages of deployment by 2020. UK businesses are establishing themselves as early innovators and are starting to license (or manufacture) the technology to other countries. The opportunity for manufacturing relates primarily to the UK market (for UK coal and gas plants), although there is some opportunity to export intellectual property and components. The Government is promoting the UK as a destination for Northern Europe to store its CO2 emissions. The relatively immaturity of CCS means that the 2,000 new jobs created within this sub-sector are mainly in research and development. However, assuming the UK maintains a strong position in the market position in CCS technology, there is the potential for significant growth in employment beyond 2020 to manufacture and install the technology on UK and Northern European fossil fuel power stations and industrial plants.

9.5.1.4 Nuclear

UK businesses are proactive in obtaining the skills, equipment, and expertise required to meet the stringent nuclear specification requirements. The nuclear programme progresses more quickly than in our previous two scenarios and three new builds become available by 2020 (two of which are configured as a twinned unit). A significant share of the value chain for the UK nuclear programmes is sourced from UK companies (c.70 per cent) leading to increased supply chain employment. This also increases the demand for the skills and expertise required to meet the stringent nuclear specification requirements.

Once UK companies have met the high standards required and are specified in the value chains, there may also be the opportunity for these companies to export components and expertise to other future nuclear projects globally.

Reducing the total number of active nuclear sites between 2009 and 2020 will lead to a decrease in nuclear employment (electricity generation and fuel processing roles will decline to 3,600 and 2,000 respectively or 49 per cent and 44 per cent of the 2009 employment). There will also be a reduction in the number of decommissioning jobs, although this will be to a lesser degree (i.e. to 11,400 or 95 per cent). Again, despite this decline, retirement-related attrition is likely to create skills gaps.

9.5.1.5 Microgeneration

Approximately 9,500 are employed (mainly within the building services engineering sector) to cope with the increased demand for microgeneration technologies. However, as in Scenario 2, unless the supply of relevant training provision is increased the growth of microgeneration could be constrained by a skills gap in terms of the number of trained and/or certified operatives.

Section 7.5 of this report introduced a vignette describing the role of Head of Sustainable Development. The following vignette describes how this career is likely to develop in relation to microgeneration technologies.

Where are they in 2020?

Our Head of Sustainable Development is now in charge of Renewable Technology Products for Worcester Bosch, a job he was appointed to in 2018. These days Worcester Bosch only really sell oil-fired Boilers for niche applications, and although many consumers have upgraded to condensing boilers, there has been a strong trend towards low carbon solutions, like Biomass and CHP. The introduction of the Feed in Tariff and Renewable Heat Incentive around 2010 significantly boosted demand for solar panel systems, ground source heat pumps, micro wind turbines and combined heat and power units.

This new Renewable Technologies Job has is an important role because it is a big area of growth for Worcester Bosch; it brought more responsibility, particularly since they expanded the manufacturing plant in Derbyshire to make renewable products at the same time.

In the last 10 years or so he has attended several internal Bosch courses, some in the UK, some in Germany, that have kept him up to date on renewable products. These courses are valuable as he needs to know the products, how they are installed, and how they perform; it is crucial that consumers not only feel they are being eco-friendly, but know that their bills will reduce.

When he reflects on how the training regime has changed over the years for their network of subcontract installers and the 500 Worcester Bosch service engineers, the difference is quite marked. Worcester Bosch has had to expand its accreditation process for subcontract installers so that they have the necessary quality mark (CORGI administered) denoting their ability to install renewable products. This has actually been quite difficult to achieve as many installers have not expanded the training of their own engineers in renewable products, or been able to keep up with the pace of growth.

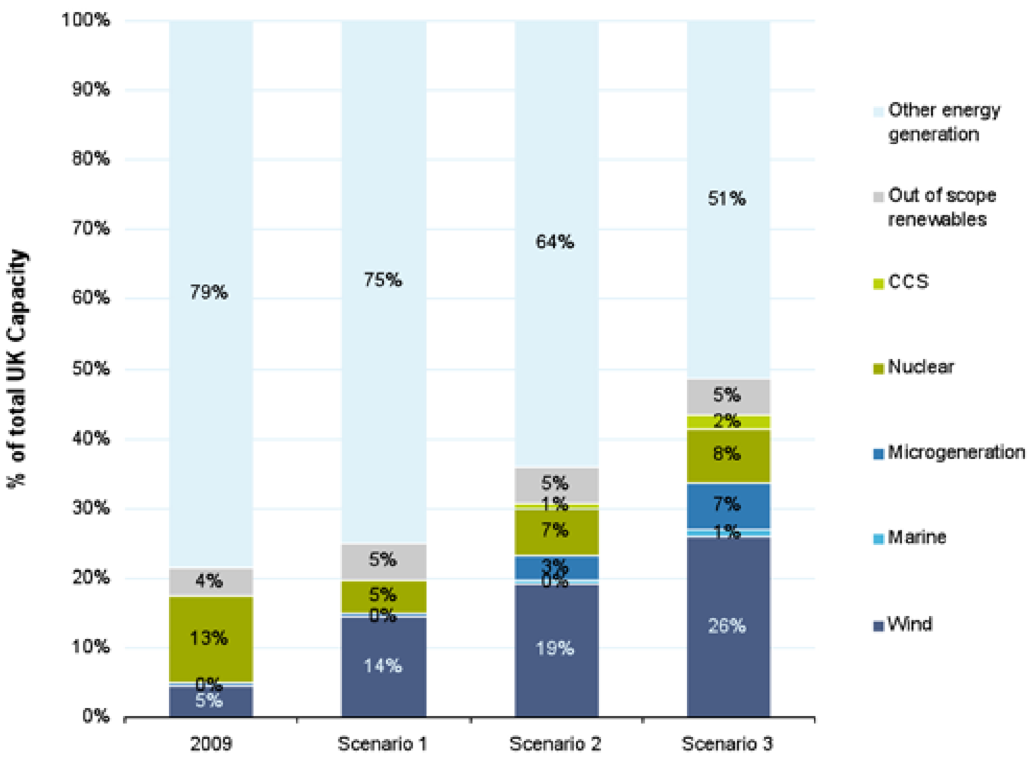
Worcester Bosch needs to make sure that its in house service engineers are completely on top of renewable technology products, particularly since they are often responsible for correcting mistakes installers have made. Worcester Bosch has been insisting on a more highly qualified entry standard (at least NQF Level 4), and last year it instituted a Renewable Technology Products Apprenticeship scheme – the first in the domestic heating industry. The apprenticeship scheme has been hugely oversubscribed, which is good, but he fears that once complete, Worcester Bosch technicians will jump ship to others in the industry willing to pay more.

Source: Subject supplied by Neil Schoffield. Story is PwC's own creation.

9.6 Overall implications for employment and skills in 2020

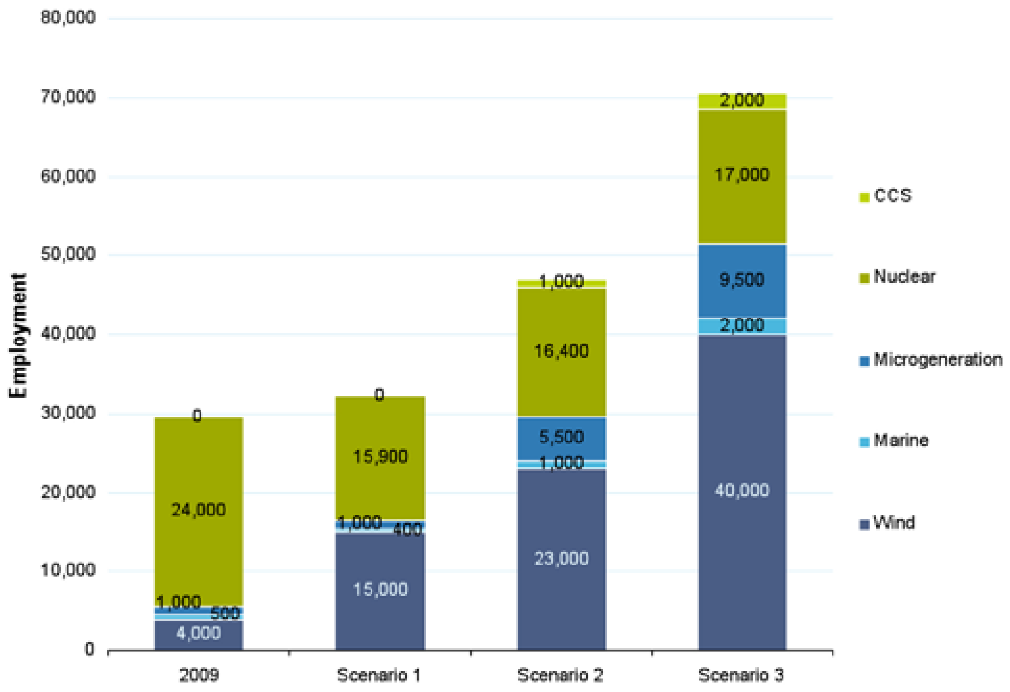
Figure 41, Figure 42 and Table 23 illustrate the number of employees and market share held by each technology in 2009 and how this number might change under each of our three scenarios.

Figure 41: UK energy generation market share by type of technology



Source: PwC analysis of stakeholder interviews and desk based review of secondary data sources. For a full list of the data sources used see Annex F.

Figure 42: Direct employment in low carbon energy generation by type of technology



Source: PwC analysis of stakeholder interviews and desk based review of secondary data sources. For a full list of the data sources used see Annex F.
Note: (1)Overall employment includes employment in construction and installation of low carbon energy generation infrastructure.

Table 23: Summary of energy generation capacity and direct employment across all three scenarios

Year	2009		2020					
Scenario name:			Scenario 1		Scenario 2		Scenario 3	
Scenario description:	Baseline		Low Governance Low Innovation		High Governance Low Innovation		High Governance High Innovation	
Technology	Energy generation (GW)	Number of employees	Energy generation (GW)	Number of employees	Energy generation (GW)	Number of employees	Energy generation (GW)	Number of employees
Wind	4	4,000	15	15,000	20	23,000	27	40,000
Marine	0	500	0	400	0.5	1,000	1	2,000
Microgeneration(1)	0	1,000	0.5	1,000	3.5	5,500	7	9,500
Out of scope renewables	3	-	5	-	5	-	5	-
Total Renewables	8	5,500	21	16,400	29	29,500	40	51,500
CCS	0	0	0	0	0.8	1,000	2	2,000
Nuclear	11	24,000	5	15,900	7	16,400	8	17,000
Total low carbon (inc. out of scope renewables)	19		26		37		50	
Total low carbon (in scope only)	15	29,500	21	32,300	32	46,900	45	70,500
Other energy generation	69	50,000	78	57,000	67	50,000	53	40,000

Source: PwC analysis of stakeholder interviews and desk based review of secondary data sources. For a full list of the data sources used see Annex F.
Note: (1) Our figure for microgeneration employment is an estimate of the total new job creation as a result of engagement in the design, manufacture, installation and maintenance of microgeneration technologies. The total FTE engaged in installation and maintenance activities is likely to be larger. However, this has been excluded from Table 23 as it represents a change in the activities undertaken by those already employed within the building services engineering sector rather than new job creation.
Note: (2) Overall employment includes employment in construction and installation of low carbon energy generation infrastructure.

As shown in Table 23, each of our three scenarios represents an increase in the number of people employed within the energy generation industry as a whole. The scale of employment and strength of the UK value chain (overall and within each technology) varies depending on the scenario. This will have a knock on effect on the number of supply chain jobs, (i.e. a well embedded value chain will have a positive impact on indirect jobs, such as component manufacture).

Over the next decade, therefore, it will be necessary to ensure that the UK has sufficient human capital to meet the increased demand, which according to our scenarios will be in the range of 10,000 to 30,000 additional direct jobs in the energy generation sector as a whole. Ideally, we would have liked to have been able to estimate how the levels of employment, outlined in each of our scenarios, breaks down in terms of job roles, in order to understand the types of skills which will be required in 2020 and beyond. However, as previously noted, there is currently no comprehensive data source for low carbon workforce statistics. Therefore our analysis has been performed at the level of individual aspects of the value chain for each technology (Table 24).

For some sub-sectors, such as wind and nuclear, the proportion of overall employment attributed to each part of the value chain vary according to the different scenarios (see Table 24). This is because employment in nuclear energy generation and fuel processing is dependant on the number of active plants. Scenario 3 assumes that the number of wind farms in the UK is sufficient to attract investment from manufacturers who establish a UK base.

Table 24 illustrates that the majority of jobs within wind energy generation in 2020 will be in the construction and installation of wind farms, which will require construction project managers and installation engineers (educated to NQF Level 5) and fabrication engineers (educated to NQF Level 3). These jobs are likely to be project based, but because of the significant level of capacity growth expected over the next 15 to 20 years, there is likely to be a relatively constant stream of projects coming through the crown estate programme for the foreseeable future.

Beyond 2020 employment in wind farms is likely to be dominated by operations and maintenance roles, for example, professional engineers, production staff and supervisors, buyers etc (as outlined in Table 6 of this report). However, growth in the off-shore wind sector (as outlined under Scenarios 2 and 3) will require significant installation capacity which involves skills in a number of operations, from initial hydrographic surveys and off-shore soil investigation, through to manufacture and installation of foundations, and then cable laying and grid connection. These operations will require a number of highly specialised skill-sets (largely with an engineering and technical focus), although the requirement for these skills will be closely tied to the availability of installation vessels in the UK and UK port capacity.

As discussed above the jobs involved in marine and CCS technologies in 2020 will be predominantly engaged in research and development activities and will require highly skilled individuals with engineering qualifications; such as mechanical and electrical engineers for marine; and process, power and design engineers for CCS. However as these technologies develop post-2020 technology transfer skills will be required to facilitate the transition from research and development to commercialisation. Also more general business and financing skill sets will be required to support the initial business idea through to rollout.

Table 24: Summary of the implications for the value chain across all three scenarios

Scenario name:				Scenario 1		Scenario 2		Scenario 3	
Scenario description:				**Low Governance Low Innovation**		**High Governance Low Innovation**		**High Governance High Innovation**	
Technology	**Low carbon job function**	**Number of employees in 2009**	**% of sub-sector employment**	**Number of employees in 2020**	**% of sub-sector employment**	**Number of employees in 2020**	**% of sub-sector employment**	**Number of employees in 2020**	**% of sub-sector employment**
Wind	Planning and development	489	12%	1,800	12%	2,760	12%	4,600	12%
	Design and manufacturing	711	18%	2,700	18%	4,140	18%	8,200	21%
	Construction and installation	1,289	32%	4,800	32%	7,360	32%	12,400	31%
	Operations and maintenance	1,111	28%	4,200	28%	6,440	28%	10,900	27%
	Technical, financial & legal services	400	10%	1,500	10%	2,300	10%	3,900	10%
	Total	**4,000**	**100%**	**15,000**	**100%**	**23,000**	**100%**	**40,000**	**100%**
Marine	Research and development	500	100%	400	100%	1,000	100%	2,000	100%
CCS	Research and development	0	-	0	-	1,000	100%	2,000	100%
Nuclear	Decommissioning	12,000	50%	11,400	72%	11,400	70%	11,400	67%
	Electricity generation	7,400	31%	2,450	15%	3,000	18%	3,600	21%
	Fuel processing	4,600	19%	2,000	13%	2,000	12%	2,000	12%
	Total Nuclear	**24,000**	**100%**	**15,850**	**100%**	**16,400**	**100%**	**17,000**	**100%**
Microgeneration(1)	Design and manufacturing	170	17%	170	17%	935	17%	1,615	17%
	Construction and installation	660	66%	660	66%	3,630	66%	6,270	66%
	Operations and maintenance	170	17%	170	17%	935	17%	1,615	17%
	Total microgeneration	**1,000**	**100%**	**1,000**	**100%**	**5,500**	**100%**	**9,500**	**100%**

Source: PwC analysis of stakeholder interviews and desk based review of secondary data sources. For a full list of the data sources used see Annex F.

Note: (1) Our figure for microgeneration employment is an estimate of the total new job creation as a result of engagement in the design, manufacture, installation and maintenance of microgeneration technologies. The total FTE engaged in installation and maintenance activities is likely to be larger. However, this has been excluded from Table 23 as it represents a change in the activities undertaken by those already employed within the building services engineering sector rather than new job creation.

(2)Overall employment includes employment in construction and installation of low carbon energy generation infrastructure.

Whilst the nuclear new build programme represents significant employment opportunities for the construction industry, direct employment in nuclear energy generation is expected to decline in the short-term. The vast majority of staff who remain directly employed in the nuclear workforce during this time will be engaged in decommissioning activities, such as technical directors, safety and environment managers and scientists, and a range of technicians (see Table 11 for a full list of job roles). However, the expected level of retirement attrition in the industry over the next decade suggests that despite the decline in overall employment in the industry there is likely to be a significant increase in the demand for experienced managerial level staff. Our stakeholder interviews indicate that the specific skills requirements that have been identified include: design engineers, geotechnical engineers, world class project managers, high integrity welders, non-destructive engineers, commissioning engineers, and nuclear safety case experts. An overall theme which has emerged in the nuclear sector is the need for employees to work to the highest quality and safety standards, which is likely to require a general up-skilling across the value chain, with an emphasis on world class project management.

A further challenge facing the nuclear industry will be how to retain experienced and skilled staff during a temporary period of decreased demand. The National Skills Academy for Nuclear is addressing the latter via the introduction of Nuclear Passports; a scheme which will allow employees to gain industry wide recognition of their skills and level of experience. The idea is that these passports will enable those employed within energy generation to move to other areas of the nuclear industry (e.g. the defence industry) until such times as they are once again required by the energy generation industry.

Qualified plumbers and electricians (NQF Level 3) will be required to undertake design, installation and maintenance of microgeneration technologies. However, as noted above, for the essential technologies (biomass boilers, CHP etc), this represents a change in the activities undertaken by those already employed within the sector rather than new job creation. Therefore, strong growth in the discretionary microgeneration technologies is expected to drive employment growth in this sector, but in terms of the actual skills involved the skills needs are not expected to change significantly, and training courses for new technologies are relatively short (i.e. two days). The types of skills which installers will need include resource assessment skills (reviewing potential for wind/solar energy), design skills, structural engineering (understanding of impact of the systems impact on building structure), 'roof working' skills, working with non-conventional electrical properties (variable voltage etc), and grid connection skills.[244]

The findings from both our desk-based research and stakeholder interviews are that low carbon jobs will not change significantly between now and 2020 in terms of their skills requirements or job descriptions. However, the projected level of employment in low carbon energy generation in 2020 and beyond, particularly in our Scenarios 2 and 3, suggest that there will need to be significant growth in the number of suitably qualified people over this timeframe.

[244] DECC (2008) Microgeneration Installation Standard: MIS 3002, Requirements for Contractors

The UK could secure the skills required for this growing industry from a range of sources:

- Skills transfer from other industries;
- Up-skilling/ training; and
- Migrant labour.

Each source is considered in more detail below.

Skills transfer from other industries

There is some potential for the low carbon industry to transfer off-shore engineering skills from the UK's oil and gas industry. Employment within this industry could be reasonably expected to decline as the uptake of low carbon energy increases. Engineers with experience in building off-shore oil and gas rigs and connecting them to the mainland, could apply their skills to the construction of off-shore wind farms, the installation of marine technologies, or the creation of a network of pipelines through which to transport CO2 for off-shore storage (in CCS).

Linked to this is the opportunity to make use of the extensive knowledge which currently exists in relation to the UK's depleted oil and gas wells. This knowledge of the structure, geology, capacity, containment measures and characterisation will be incredibly valuable to the CCS industry in terms of identifying potential storage sites.

The design, installation and maintenance of microgeneration technologies is currently being implemented by individuals within the building services engineering sector, who have acquired the relevant underpinning knowledge, in terms of system design, integration with other technologies and for some technologies – health and safety. Our research does not indicate that this is likely to change greatly over the next decade.

Migrant labour

Migration could facilitate the sharing of CCS knowledge and intellectual property, for example, by recruiting individuals from the US enhance oil recovery industry that have the necessary skills and experience to develop a network of pipelines for transporting CO2 within the UK.

Up-skilling/training

The transition from the research phase to proof of concept to large scale deployment and commercial exploitation of technologies such as marine and CCS, and to a lesser extent off-shore wind, will require the effective engagement of technology transfer skills and roles. Most universities and research organisations have technology transfer offices in place, therefore the successful commercialisation of emerging low carbon technologies will depend upon research staff being aware of what these offices do and how and when to access their support.

Key issues for addressing the ageing nuclear workforce will be attracting enough apprentices into the industry and maintaining appropriate progression rates for technical roles. The industry does not foresee any potential shortages in graduate recruitment.

The current reliance of on migrant labour within the building services engineering sector has the potential to result in staff shortages (and therefore create skills gaps and shortages) for the sector going forward as many migrant workers may choose to return to their country of origin or move on to other countries which are able to offer more attractive employment packages, given the current economic climate. Therefore more should be done to encourage new entrants into this sector, which will play a key role in the deployment of microgeneration technologies in the UK.

The need to develop leadership and management skills within the industry was also noted. While this is a generic issue for UK industries as a whole, the potential for this to negatively impact on productivity makes it is an important one for the industry to address. Therefore the industry should do more to develop leadership and management competencies which are appropriate to the needs of low carbon energy generation.

The importance of STEM skills to the low carbon industry as a whole has been well documented, therefore the ability to attract STEM students at all levels, amid growing competition will influence the sector's ability to develop and retain a highly skilled workforce.

Another issue identified by our scenarios is that the UK has the opportunity to strengthen the value chain of low carbon energy generation. A well-embedded value chain will maximise the potential for job creation and increase the demand for manufacturing skills to 2020 and beyond. The decline of the UK's manufacturing industry means that significant training and up-skilling will be required if the UK is to take advantage of the manufacturing opportunities presented by the low carbon industry.

10 Conclusions

The low carbon sector is a relatively small sector in terms of direct employment. Our overall estimate for direct employment in the sector is 30,000, some 24,000 of which are in the nuclear sub sector, with the balance of 6,000 being in the renewables sectors, primarily in wind. [245]

There is a strong view, not only in the Low Carbon Industrial Strategy, but also amongst the industry stakeholders that we spoke to as part of this study, that every job must become, in effect, a 'green' job in the years to come. The Strategy also acknowledges the labour market information gaps in the sector and states that the Government will work with employers, SSCs and the UK Commission to develop "the practical and analytical capability to collect, process and deploy intelligence on skills needs in key sectors [including low carbon] and markets quickly and effectively."

In general, the energy workforce is highly skilled with almost 40 per cent of staff educated to NQF Level 4 or 5 compared to the UK average of around a third. However, the level of qualification varies considerably across occupations and a substantial majority of energy employers report skills shortages in relation to technical, practical or job specific skills.

Our research has confirmed there are persistent skills shortages across the sector, across most engineering disciplines both for highly qualified engineers and experienced technicians, for project managers with an engineering qualification, but also in more specialised areas such as geologists and marine and aeronautical engineers. Concerns around the number of school-age students opting for STEM subjects at GCSE and A-level, coupled with a reported shortage of teachers in STEM subjects (OECD, 2007), are likely to exacerbate the supply of STEM students unless steps are taken to make not only these subjects and but also related careers more attractive at all levels of our education system. Table 25 presents a summary of the skills gaps and shortages in low carbon generation.

[245] These figures include employment in the construction and installation of low carbon energy generation infrastructure.

Table 25: Summary of skills gaps and shortages in low carbon energy generation

Technology	Wind	Marine	CCS	Nuclear	Microgeneration
Estimated direct employment in 2009	• 4,000	• **500**	• **0**	• **24,000**	• **1,000**
Sector specific skills gaps and shortages	• Business Development Managers with project management skills (NQF Level 5) • Mechanical Engineers (NQF Level 5) • Structural Engineers (NQF Level 5) • Geologists (NQF Level 5) • Civil engineers (NQF Level 5) • Aeronautical Engineers (NQF Level 5) • Project Managers (NQF Level 4) • Electrical Engineers to connection wind farms to the Grid (NQF Level 4) • Engineering technicians (NQF Level 3/ 4) • Turbine technicians (NQF Level 3) • STEM specialists generally (NQF Levels 4 and 5)	• Civil engineers (NQF Level 5) • Mechanical engineers (NQF Level 5) • Marine engineers (NQF Level 5) • Electrical engineers (NQF Level 4)	• Process engineers (NQF Level 4) • Power engineers (NQF Level 4) • Design engineers (NQF Level 4) • Knowledge of off-shore storage/site characterisation/ geology	• Technical staff (NQF Levels 2 and 3) • Design engineers • Planners and estimators • Geotechnical engineers • Project managers • High integrity welders • Manufacturing engineers • Non-destructive engineers • Commissioning engineers • Nuclear safety case experts. A gap of highly skilled and experienced personnel is predicted to emerge driven mainly by retirement attrition	• **Qualified trades trained in microgeneration technologies (NQF Level 3)**
Generic skills gaps and shortages in the UK which will impact the sector	• Management and leadership skills	• **Technology transfer skills** • **STEM skills**	• **Technology transfer skills** • **Service sector consultants (e.g. legal and financial advice and climate change economics)**	• **Management and leadership skills**	• **Management and leadership skills** **Commercialisation skills**

Source: PwC analysis of stakeholder interviews and a desk based review of secondary data sources, including: AEA (2008) Future Value of Coal Carbon Abatement Technologies to UK Industry; Bain & Co. (2008) Employment opportunities and challenges in the context of rapid industry growth; Innovas (2009) Low Carbon and Environmental Goods and Services: an industry analysis; BWEA (2009) Small Wind Systems UK Market Report; Carbon Capture and Storage Association (2009) Carbon Capture and Storage – building a low carbon economy; Cogent (2008) Energy Skills: Opportunity and Challenge. A Response to the Energy White Paper; Cogent (2008) Nuclear Industry Factsheet; Cogent (2009) Power People: The Civil Nuclear Industry 2009-2025; Cogent website (Available at: http://www.cogent-careers.com/roles/search and http://www.cogent-ssc.com/industry/nuclear/industry_profile.php, last accessed 21st October 2009); EU Skills (2007) Occupational and Functional Map Renewable Energy Sector; Greenpeace (2006) Solar Generation: electricity for over 1 billion people and 2 million jobs by 2020; IBM (2006) An Evaluation of the capability and capacity of the UK and global supply chains to support a new nuclear build programme in the UK; IPPR (2009) The future's Green: Jobs and the UK low-carbon transition; SQW (2008) Skills and employment in the wind, wave and tidal sectors; and SummitSkills (2008) Report on additional research into specific themes arising from the Sector Skills Agreement for building services engineering.

Note:(1)Overall employment includes employment in construction and installation of low carbon energy generation infrastructure.

Current vocational qualifications and training provision will also have to adapt to the needs of low carbon employers and adult workers, particularly in light of the fact that a significant proportion of the current workforce will still be in place in 2020.

Wind and nuclear are expected to account for a significant proportion of the capacity installed or under construction in the UK in 2020 (representing between 35 per cent and 52 per cent of total employment in energy generation and between 19 per cent and 33 per cent of total energy output depending on the scenario), and our interviews suggested these sectors will have the most significant impact on employment and skills requirements in 2020.

Marine and carbon capture and storage are two emerging areas in which the UK appears to have a strong position – with the potential to become a global market leader. These technologies are at a much earlier stage of development than wind. While the scope of this study is to 2020, these technologies are unlikely to reach maturity before this date. It is clear, however, that if growth in these sub-sectors is to be achieved, consideration should be given now to developing the necessary pipeline in terms of employment and skills required.

Small scale microgeneration, particularly for heat energy, is an important growth area in the Renewable Energy Strategy and deployment is expected to increase in importance.

In our optimistic scenario of how the overall sector might grow, where the UK becomes the largest global market for off-shore wind and develops a strong market positions in CCS and marine technologies, we would anticipate a significant increase in low carbon direct employment – driven primarily by wind. This increase, however, would be offset to some extent by declining employment in carbon rich energy generation sectors, and in nuclear (as existing plants are decommissioned). Overall we do not anticipate dramatic net increases in direct employment in the power generation sector as a whole. In the period to 2020, in our optimistic scenario, we expect marine and CCS to begin to make an, albeit small, contribution to direct employment. It should be noted, however, that while indirect employment is beyond the scope of this study, growth in low carbon energy generation is also likely to lead to increased demand for associated technical consulting and financial services skills both in the UK and beyond. This demand will provide opportunities for indirect employment growth and will also impact on future skills provision.

It is likely that there will be markedly different levels of employment in different parts of the value chain. Growth in the wind sector will generate significant employment in construction and installation and in operation and maintenance of wind farms, but will also drive indirect employment for example in the high-voltage engineering required to connect new installations to the National Grid. Manufacturing jobs will be created in the period to 2020, particularly if Government is able to encourage the return of a major wind turbine manufacturer to the UK.

Our view is that the challenge for future skills is primarily two-fold; a need to re-skill the existing workforce rather than to create a new low carbon or renewables workforce, while increasing the supply of STEM graduates entering the industry long-term. There is a great deal of potential for transferable skills and knowledge from the UK off-shore oil and gas industry, and other industries; the construction and installation skills required in off-shore oil and gas can be applied to off-shore wind farms and the expertise and knowledge of depleted oil and gas fields in the North Sea is fundamental to the successful storage of CO2.

There is no clear evidence that technical jobs in the sector will change markedly over the next decade, with differences emerging, rather as a matter of degree, particularly in microgeneration. There is some likelihood, however, that a range of supporting roles may emerge, relating to sales and marketing for example, that are more focused on communicating the benefits of low carbon to consumers and the general public.

Overall, there is still a level of uncertainty in the market for low carbon energy generation and much will depend on the effectiveness of the Government's measures to support the industry and to overcome the barriers to growth identified in the Foresight section of this report. These include: strengthening the links between businesses and HE and FE; investing in reskilling the existing workforce; making the sector a more attractive place to work; facilitating skills transfer from other sectors and strengthening the value chain – particularly in regard to manufacturing.

Annex A: Employment and skills in the energy sector as a whole

In the absence of detailed employment statistics on the electricity gas and water supply sector, the following analysis of the occupational profile has been undertaken across mining and quarrying and electricity, gas and water supply. The subsequent analysis of training provision and skills shortages and gaps focuses exclusively on the electricity, gas and water supply sector.

In 2007, 212,000 people were employed within mining and quarrying, electricity, gas and water supply. The breakdown of this employment is shown in Table 26.[246]

Table 26: Employment within mining and quarrying, electricity, gas and water supply in 2007

Standard Industrial Classification (Revised 1992) (Revised 2003) Section Division Group Class	Description	Total employment – average during the year
C	Mining and quarrying	60,000
E	Electricity, gas and water supply	152,000
40	Electricity, gas, steam and hot water supply	123,000
40.1	Production and distribution of electricity	82,000
40.2	Manufacture of gas; distribution of gaseous fuels through mains	*
40.3	Steam and hot water supply	*
41	Collection, purification and distribution of water	29,000

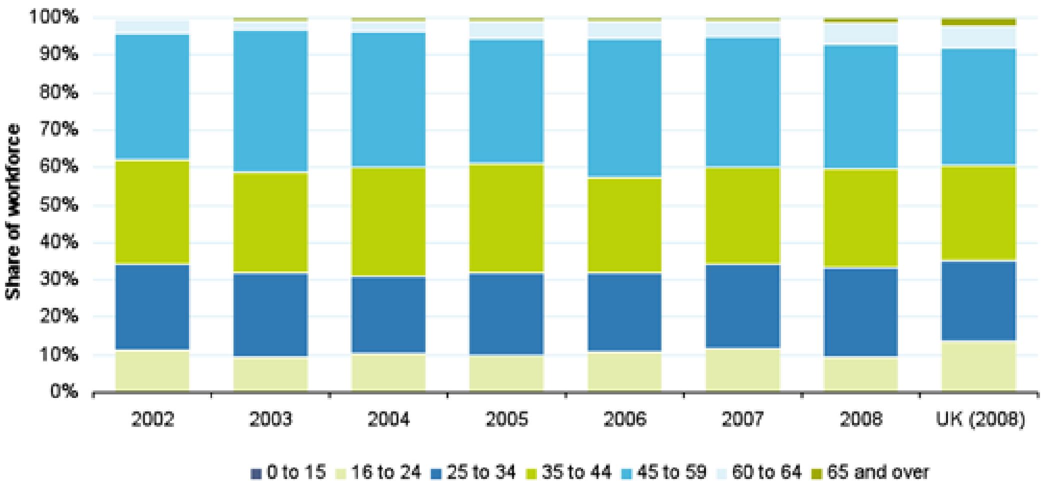
Source: ONS (2009) Annual Business Inquiry in UK Employment and Skills Almanac 2009

The workforce profile is predominantly male (accounting for over three quarters of the workforce in 2008).[247] This is slightly out of sync with the gender breakdown of people qualified in STEM within the UK at this time, which is 72 per cent male and 28 per cent female.[248] Although there is significant variation across STEM subjects; qualifications in applied medicine and biological sciences are more popular amongst women than engineering.

Figure 43 shows that the mining and quarrying, and electricity, gas and water supply sector has marginally more people in the 45-59 age group than the UK average. The proportion of the workforce which is 65 and over is smaller than the UK average but is growing.

[246] ONS (2009) Annual Business Inquiry in UK Employment and Skills Almanac 2009
[247] ONS (2009) LFS/ IER in UK Employment and Skills Almanac 2009
[248] UKRC (2009) Analysis of Office for National Statistics; Quarterly Labour Force Survey, January - December, 2008.

Figure 43: Employment within mining and quarry, electricity, gas and water supply by age



Source: ONS (2009) LFS/IER in UK Employment and Skills Almanac 2009

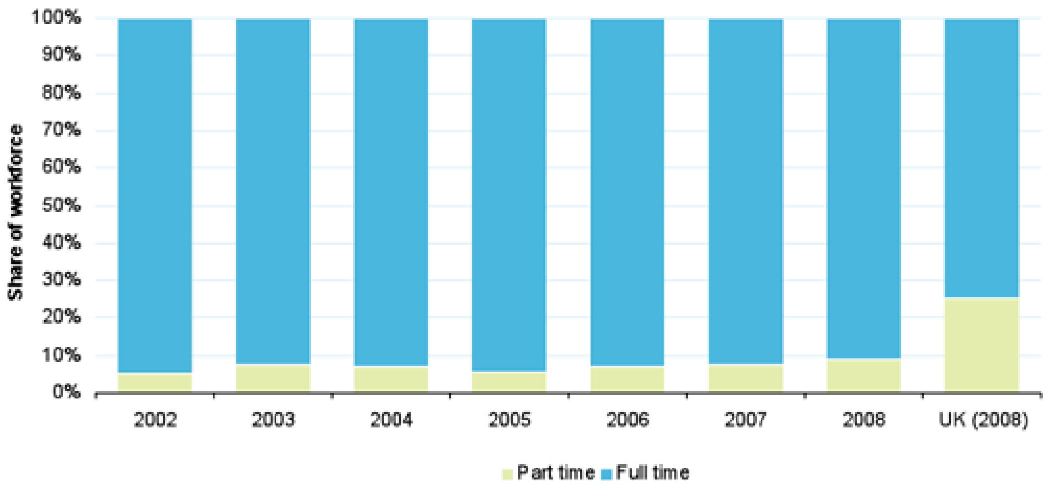
The industry employs much fewer people on a self employed basis, compared to the UK average (see Figure 44).

Figure 44: Employment within mining and quarry, electricity, gas and water supply by employment status

Source: ONS (2009) LFS/IER in UK Employment and Skills Almanac 2009

Figure 45 illustrates that there are also much fewer part-time workers compared to the UK average.

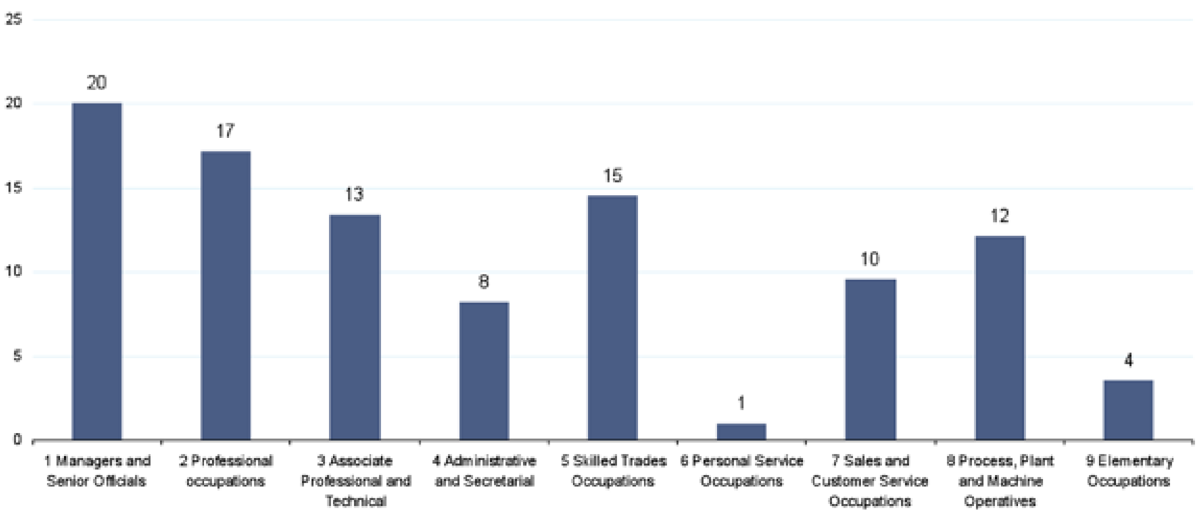
Figure 45: Employment within mining and quarry, electricity, gas and water supply by working arrangement



Source: ONS (2009) LFS/IER in UK Employment and Skills Almanac 2009

Figure 46 shows the occupational profile of the industry. The majority of the workforce is employed in professional, associate professional or skilled roles.

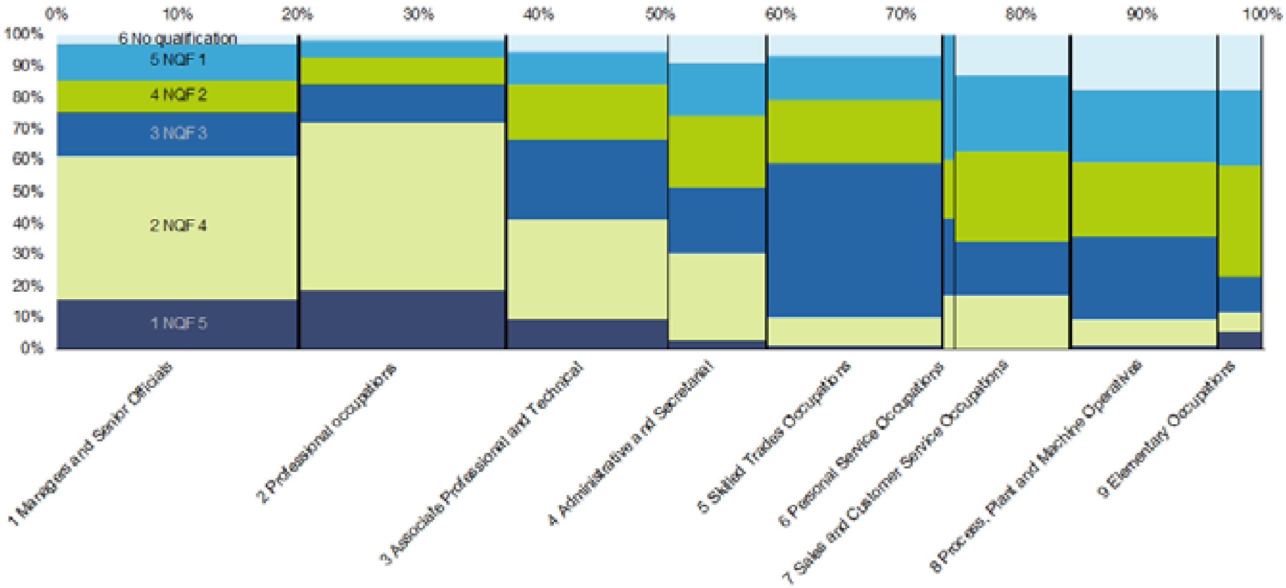
Figure 46: Occupational profile of the mining and quarrying and electricity, gas and water supply workforce



Source: ONS (2009) LFS/ IER in UK Employment and Skills Almanac 2009

In general the workforce is highly skilled with almost 40 per cent of staff educated to NQF Level 4 or 5 compared to the UK average of around a third. However, the level of qualification varies considerably across occupations (see Figure 47).

Figure 47: NQF Level of the workforce by occupation of the mining and quarrying and electricity, gas and water supply workforce



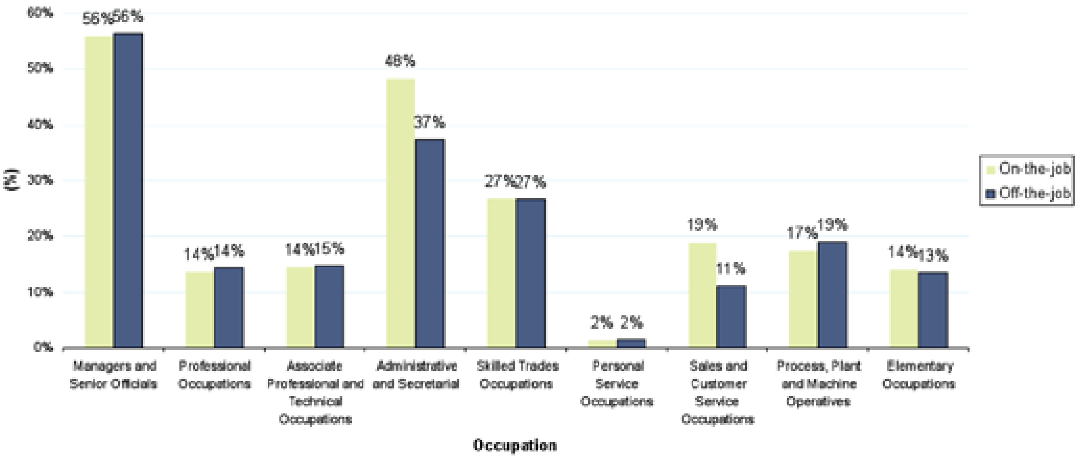
Source: ONS (2009) LFS/ IER in UK Employment and Skills Almanac 2009

The Learning and Skills Council's 2007 National Employers Skills Survey (NESS) reported a spend of over £530m on training for the electricity, gas and water industry in the preceding 12 months, with the majority of establishments (81 per cent) either funding or arranging staff training during this time (i.e. including both on-the-job and/or off-the-job training). Figure 48 displays the proportion of establishments providing on-the-job and/or off-the-job training for their employees. As the chart shows establishments were most likely to be training Managers and Senior Officials, followed by Administrative and Secretarial staff and Skilled Trades. On average employees received 9.2 days training over the 12 month period. However, this was affected by the size of the establishment, with employees of very small firms receiving one and a half days less training, on average, than larger organisations.[249]

The main reason given for not providing training was that all staff are fully proficient (by 70 per cent of establishments). 3 per cent of establishments felt that external training courses were too expensive, while 2 per cent felt that training was not needed because they were a small firm.

[249] Firms with: 2-4 employees received an average of 7.9 days training; 5-24 employees received an average of 8.8 days training; 25-99 employees received an average of 9.1 days training; and 100+ employees received an average of 9.4 days training. (Source: NESS, 2007 in UK Employment and Skills Almanac 2009)

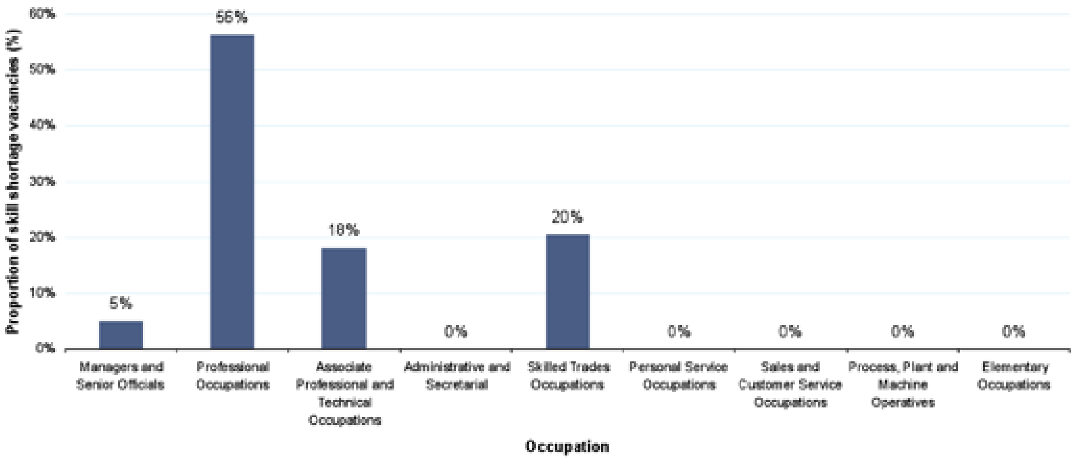
Figure 48: Proportion of establishments providing on-the-job and off-the-job training by occupation for electricity, gas and water



Source: NESS, 2007 in UK Employment and Skills Almanac 2009

200 skills shortage vacancies were reported by 2 per cent of establishments engaged in economic activity relating to electricity, gas and water.[250] This equated to over 6 per cent of all vacancies and less than 1 per cent of total employment in these activities. The vast majority of skills shortage vacancies were reported in Professional Occupations, followed by skilled trades as shown in Figure 49.

Figure 49: Proportion of skill shortage vacancies by occupation for electricity, gas and water

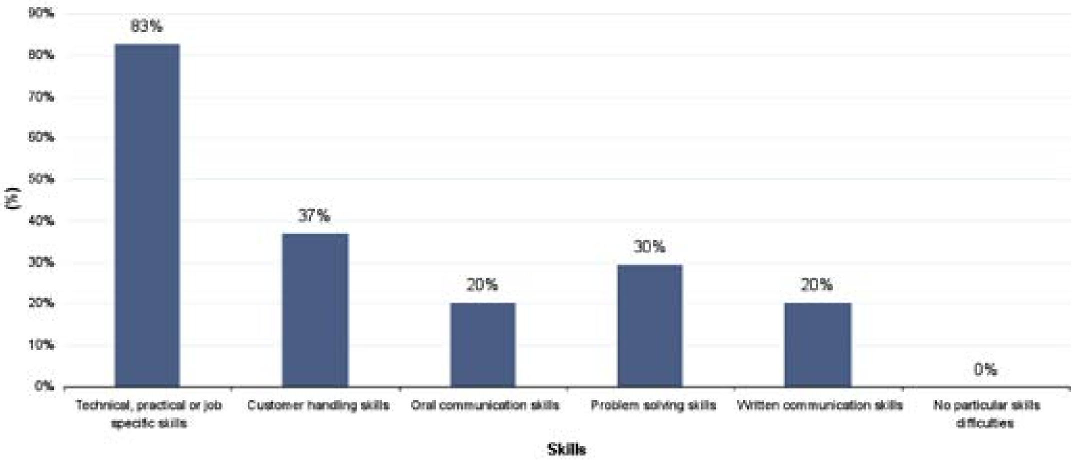


Source: LSC (2007)

The types of skills which employers found difficult to obtain in these skills shortage vacancies are shown in Figure 50. These were predominantly technical, practical or job specific skills.

[250] NESS, 2007 in UK Employment and Skills Almanac 2009

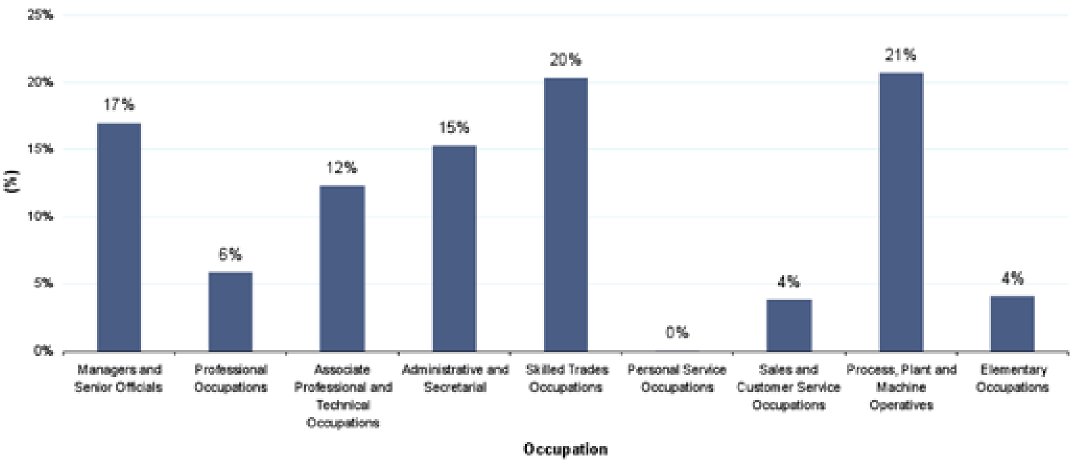
Figure 50: Skills found difficult to obtain in skill shortage vacancies for electricity, gas and water



Source: LSC (2007)

In addition to skills shortage vacancies, 16 per cent of establishments reported 6,700 skills gaps, accounting for five per cent of employment.[251] As illustrated in Figure 51 skills gaps were more evenly distributed across occupational categories than skills shortage vacancies.

Figure 51: Proportion of skill gaps by occupation for electricity, gas and water

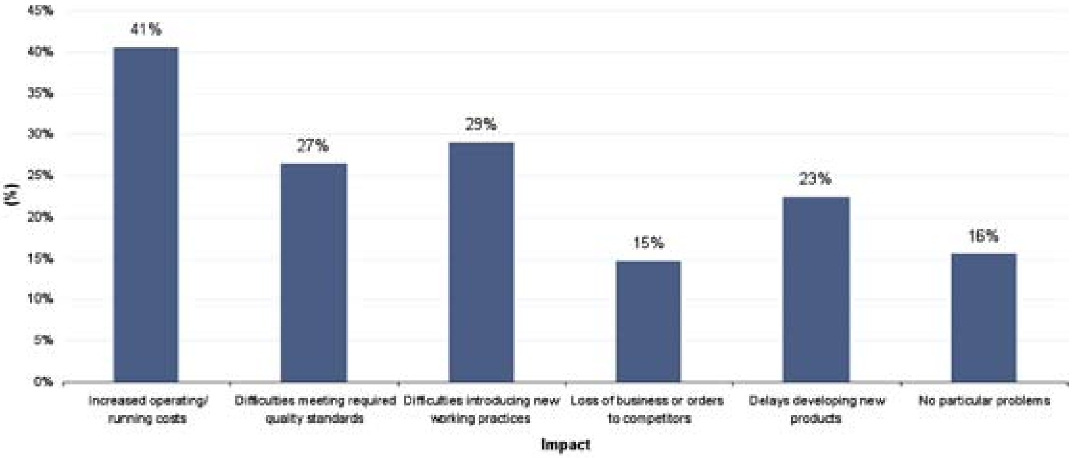


Source: LSC (2007)

The main cause of these skills gaps was a lack of experience or due to the individual being recruited recently (69 per cent), followed by a failure to train and develop staff (26 per cent) and a lack of staff motivation (25 per cent). The inability of the workforce to keep up with change was cited for 18 per cent of skills gaps, while 17 per cent of gaps were due to recruitment problems. The impact of these internal skills gaps were more wide ranging that that of the skills shortage vacancies, as shown in Figure 52.

[251] NESS, 2007 in UK Employment and Skills Almanac 2009

Figure 52: Impact of internal skill gaps for electricity, gas and water



Source: LSC (2007)

Annex B: The National Qualifications Framework

National Qualifications Framework (NQF)

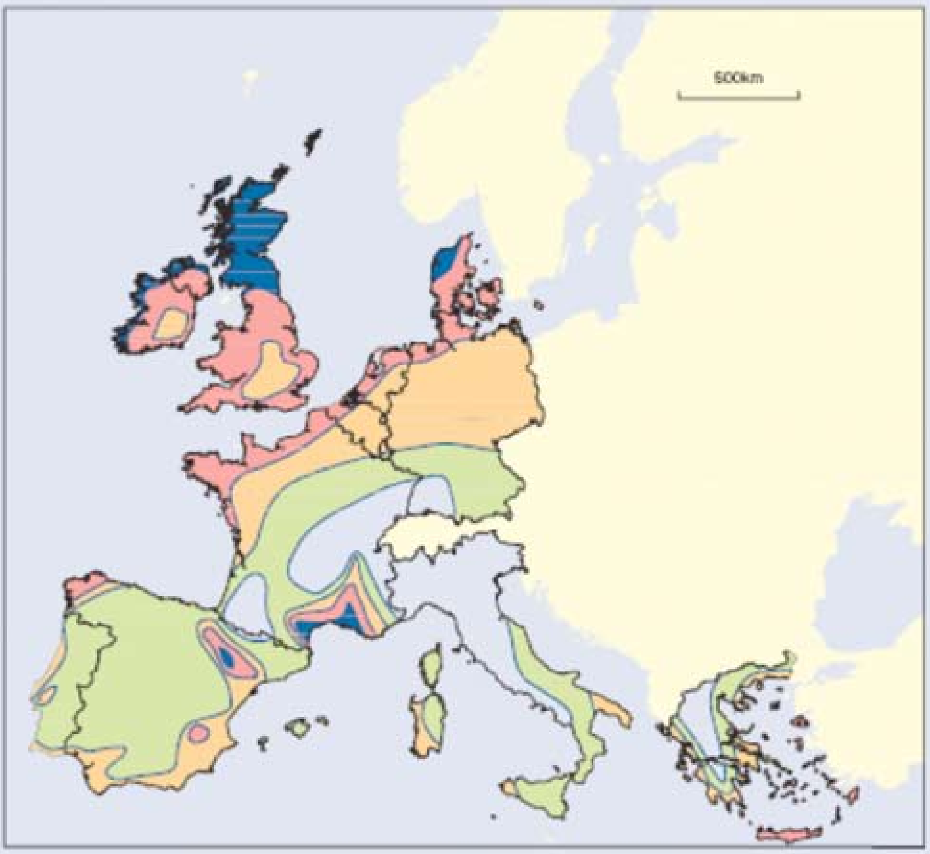
Previous levels (and examples)	**Current levels (and examples)**	**Framework for Higher Education Qualifications (FHEQ)**
5 Level 5 NVQ in Construction Management Level 5 Diploma in Translation	8 Specialist awards	D (doctoral) Doctorates
	7 Level Diploma in Translation	M (masters) Masters degrees, postgraduate certificates and diplomas
4 Level 4 NVQ in Advice and Guidance(1) Level 4 National Diploma in Professional Production Skills Level 4 BTEC Higher National Diploma I 3D Design Level 4 Certificate I Early Years	6 Level 4 National Diploma in Professional Production Skills	H (honours) Bachelor degrees, graduate certificates and diplomas
	5 Level 5 BTEC Higher National Diploma in 3D Design	I (intermediate) Diplomas of higher education and further education, foundation degrees ad higher national diplomas
	4 Level 4 Certificate in Early Years	C (certificate) Certificated of higher education
3 Level 3 Certificate I Small Animal Care Level NVQ in Aeronautical Engineering A Levels		
2 Level 2 Diploma for Beauty Specialists Level 2 NVQ in Agriculture Crop Production GCSEs Grades A*-C		
Level 1 Certificate in Motor Vehicle Studies Level 1 NVQ in Bakery GCSEs Grades D-G		
Entry Entry Level Certificate in Adult Literacy		

Source: Qualifications and Curriculum Development Agency (2009)

Annex C: EWEA European on-shore wind atlas

Figure 53: EWEA European on-shore wind atlas

Figure 5.3: European Wind Atlas, onshore



Wind resources at 50 metres above ground level for five different topographic conditions

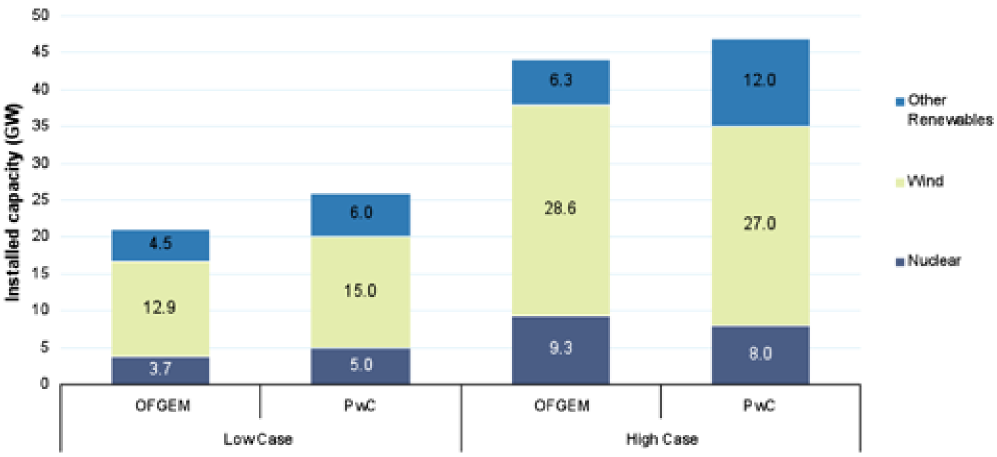
	Sheltered terrain		Open terrain		At a sea coast		Open sea		Hills and ridges	
	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}
	>6.0	>250	>7.5	>500	>8.5	>700	>9.0	>800	>11.5	>1800
	5.0–6.0	150–250	6.5–7.5	300–500	7.0–8.5	400–700	8.0–9.0	600–800	10.0–11.5	1200–1800
	4.5–5.0	100–150	5.5–6.5	200–300	6.0–7.0	250–400	7.0–8.0	400–600	8.5–10.0	700–1200
	3.5–4.5	50–100	4.5–5.5	100–200	5.0–6.0	150–250	5.5–7.0	200–400	7.0–8.5	400–700
	<3.5	<50	<4.5	<100	<5.0	<150	<5.5	<200	<7.0	<400

Source: EWEA (2009) Wind Energy – the facts

Annex D: Comparison of PwC and Ofgem scenarios

Our scenarios illustrate a range of potential outcomes for low carbon energy generation to 2020. A wide number of industry bodies have also developed scenarios for the market. Our interviews with key stakeholders identified the Ofgem energy market scenarios (Project Discovery, released in October 2009) as a useful point of comparison for our work. Figure 54 illustrates both the Ofgem and PwC perspectives:

Figure 54: PwC and Ofgem low carbon energy scenarios to 2020



Source: PwC analysis of stakeholder interviews and a desk based review of secondary data sources (Annex F), including Ofgem (2009)
Note: High case represents the highest level of deployment for low carbon technologies. Low case represents the reverse.

Our research has considered scenarios from Ofgem and a number of other sources (Element Energy, SKM etc), and triangulated these views with the findings from our stakeholder interviews in order to develop our own scenarios. We believe that even in the low case, there will be a reasonable level of growth in renewables and that considering recent developments, the nuclear new build programme is likely to go ahead to some extent, even if construction is slower than expected. In the high case we have adopted a more optimistic view of microgeneration deployment which is inline with the possible futures identified through our research.

Annex E: Glossary

Term	Definition
ASHP	Air Source Heat Pumps
CCS	Carbon Capture and Storage
CSLF	Carbon Sequestration Leadership Forum
CSH	Code for Sustainable Homes
CHP	Combined Heat and Power
CSP	Concentrating Solar Power
DECC	Department of Energy and Climate Change
ECA	Electrical Contractors Association
EPSRC	Engineering and Physical Sciences Research Council
EPC	Engineering, Procurement and Construction
EMEC	European Marine Energy Centre
FIT	Feed in Tariff
GDA	Generic Design Assessment
GSHP	Ground Source Heat Pumps
HVDC	High Voltage Direct Current
ISPs	Independent Service Providers
IPC	Infrastructure Planning Commission
IP	Intellectual Property
LCEGS	Low carbon and environmental goods and services
NESS	National Employers Skills Survey
NEF	National Energy Foundation
NAMTEC	National Metals Technology Centre
NPSs	National Policy Statements
NaREC	New and Renewable Energy Centre
OND	Office for Nuclear Development
ORED	Office for Renewable Energy Development
O&M	Operation and Maintenance
OEMs	Original Equipment Manufacturers
PwC	PricewaterhouseCoopers LLP
ROCs	Renewables Obligation Certificates
SSCs	Sector Skills Councils
SMEs	Small and Medium Enterprises
STEM	Science, Technology, Engineering and Mathematics
LCBP	The Low Carbon Buildings Programme
NAMTEC	The National Metals Technology Centre
RAB	The Renewables Advisory Board
SCCCS	The Scottish Centre for Carbon Capture and Storage
ZCH	Zero Carbon Homes
WECs	Wave Energy Convertors

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