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The manufacturers' organisation

In partnership with Deloitte.

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Delivering the low-carbon economy – Business opportunities for UK manufacturers

Contents

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Foreword

The low-carbon economy could provide UK manufacturing with a truly significant opportunity. Some of you might be surprised by this comment, as climate change has already made a forceful impact on the manufacturing sector, with the prospect of more constraints emerging.

There is no doubt that UK manufacturing will have to modify the way in which it designs and produces goods as more government regulation and directives from Europe directly associated with climate change come into play. But it is also consumer demand that will necessitate a massive transformation – a 21st century industrial revolution, if you like.

There is much dialogue surrounding the low-carbon economy, some of it pessimistic about the outcome of these changes. The UK has a wide range of innovative manufacturers who can play a major role in helping the world to cut its emissions. For forward-thinking businesses, the prospect of getting involved in an emerging sector is immense.

Our collaboration with EEF, which is at the forefront of identifying the challenges facing UK manufacturers, has revealed some fascinating evidence and encouraging signs that manufacturers are already establishing a world-class reputation in developing sectors.

As governments advance their controls on carbon emissions, ambitious manufacturers who can see beyond the short-term challenges of increased regulation to the significant prospects beyond, will I believe, reach their objective. And in so doing, contribute towards the fundamental changes needed to ensure continued life on our planet.

Jane Lodge
UK Manufacturing Industry Leader, Deloitte

Summary

Combating climate change is a major challenge

Governments around the world are getting serious about combating climate change. Targets for cutting carbon emissions and plans for achieving this are being prepared. The UK has one of the most ambitious targets, with the government aiming to reduce, by 2050, our carbon emissions to at least 60% below their 1990 level.

To achieve this target, we will need to make fundamental changes in the type of energy we use and how we use it. This will have a major impact on how we work, how we live and how we travel. Manufacturers will face a major challenge to make substantial improvements in their energy efficiency, requiring many of them to radically rethink their processes. Companies in some industries will also be concerned about the impact of potential environmental taxes (and other measures) on their competitiveness.

There are significant opportunities

At the same time, climate change will create major opportunities for business to develop, make and sell low-carbon products and services. In this report, we look at three markets in detail – low-carbon energy, motor vehicles and energy efficiency. The UK has significant strengths in all these areas and the potential to make major inroads in these markets. As one of the leading nations in taking action to combat climate change, the UK should also be well placed to take advantage of the opportunities associated with it.

The UK has significant potential to develop its offshore wind and marine (wave and tidal) renewable industries. It possesses the best wind energy resource in Europe. The potential size of the offshore market and specialist marine engineering capabilities should make the UK an attractive investment location, especially for next-generation turbines designed for offshore deployment. However, UK producers face significant challenges in breaking into well-established global supply chains. Similarly, the UK possesses the largest marine energy resource in Europe and has a range of transferable skills and capabilities stemming from the oil and gas, shipbuilding and power generation sectors.

The global market for clean coal technologies is likely to grow substantially, given that coal is used to generate 40% of the world's electricity and is forecast to remain the dominant fuel for power generation over the coming decades. The UK's strengths in the power, process engineering and offshore engineering industries, the offshore infrastructure stemming from the petroleum industry and an extensive carbon storage capacity all leave it well positioned to take advantage of these opportunities. Two sets of clean coal technologies have particular potential to reduce emissions from coal-fired plant – advanced combustion technologies and carbon capture and storage (the removal, transport and storage of the carbon dioxide emissions from a coal plant).

A range of new vehicle technologies and fuels exist which could lower the carbon footprint of the roads transport sector. Two major areas of opportunity for UK manufacturers are in internal combustion engines and hybrid and electric vehicles. The UK is well placed on engines, given that it accounts for between 25% and 30% of European production. We also possess a number of market-leading designers and developers of engines and engine-related technologies. However, the UK automotive engine industry faces a growing challenge from low cost countries, which are beginning to play a significant role in the manufacture of vehicles and engines. UK industry also has significant expertise in a range of key technologies for hybrid cars, such as control systems and electric drivetrains. In the short-term however, lack of both consumer demand and of a long-term carbon reduction policy are likely to constrain the market for hybrid vehicles.

Business opportunities in energy efficiency are dominated by motor systems in industry and boilers in the home. Motor systems account for nearly 60% of energy consumption in business. There is considerable scope to increase their energy efficiency. Variable speed drives can reduce the electricity consumption of motor systems by better matching the speed of the motor to the requirements of the application. Rising energy prices and awareness of the financial benefits of greater energy efficiency are set to grow the market for variable speed drives and the UK has a number of companies either manufacturing them or offering design and integration services. To realise these opportunities however, the industry needs to develop ways to communicate the financial benefits more effectively to the end user.

Domestic heating accounts for a quarter of total energy consumption in the UK. We are the largest gas boiler market in Europe and are major designers and manufacturers of boilers. In the near term, most opportunities will probably be in high-efficiency condensing boilers, which recover and recycle most of the wasted heat that is lost to the atmosphere from the flue of a conventional boiler. Building regulations require all new installations to be high-efficiency condensing boilers. However, boilers tend to be replaced only every 15-20 years at the end of their working life and incentives will be needed to accelerate the replacement cycle.

Realising the opportunities

Despite the advantages it possesses, the UK will fail to realise the opportunities presented by a low-carbon economy, unless both business and government are alert to what they need to do.

The government has a key role to play in supporting the development of low-carbon products and removing the barriers that stand in their way. It has made a good start by setting out clear goals to reduce carbon emissions over the next 50 or more years and establishing a Committee on Climate Change to monitor progress and develop the required policies. However, it needs to reinforce this by working with its partners in the European Union to ensure that its policies, and the EU Emissions Trading Scheme in particular, send out a signal on the long-term carbon price to potential investors in low-carbon products.

The same comments apply to road transport where any policy to constrain carbon dioxide emissions from road transport must have a long time horizon and respect the product development cycles of manufacturers. The government also needs to ensure that regulation, particularly that relating to product standards, makes it clear to manufacturers what is expected of them but encourages innovation by focusing on the outcomes themselves rather than how they are achieved.

The government must also ensure that the planning system does not impede the development of a low-carbon economy and prevent business from realising the opportunities associated with it. Currently, planning remains a major barrier to the pace of renewable energy deployment. The government must therefore deliver on its commitments to speed up the planning process.

It is also important that the government provides the support that will ensure manufacturers can undertake research and development (R&D) to develop the next generation of products in the UK. Currently, public funding for energy-related R&D is very low compared with other industrialised nations. Government should use a portion of the revenues raised by auctioning permits (to emit carbon dioxide in the EU ETS) to fund the increase. It must also invest in the science and technology skills required to develop and manufacture new low-carbon products.

Manufacturers must be pro-active

This is by no means a one-way street – business also has a lot to do if it is to realise the opportunities presented by a low-carbon economy. It needs to be creative in thinking about the opportunities that the low-carbon economy will present to develop new products and markets. Manufacturers must also not neglect the service opportunities associated with the low-carbon economy, given the contribution that services can make to their profitability.

They will also need to act quickly to link into the supply chains being formed to produce the new low-carbon products and establish an early toehold in emerging global markets. The risks and expense involved in developing new low-carbon products means that UK manufacturers will also increasingly need to look at identifying potential collaborative partners. Alongside the government, industry must also make the commitment to invest in the R&D and skills required to deliver the low-carbon economy.

Firms also need to look beyond their current relationships and approaches to markets. For example, the key role that manufacturing will play in the low-carbon economy gives it the chance to improve its profile and image, particularly amongst those who would not normally consider a career in industry. More firms need to engage with schools to inspire teachers and students with what they are doing to deliver a low-carbon future. They also have a major role to play in growing the market for low-carbon products by educating consumers on how these products can cut their energy use, save them money and reduce carbon emissions.

Consumers need to know

Similarly, manufacturers, energy suppliers and the government need to work together to accelerate the uptake of products that will save consumers money in the long-term but which have large upfront costs. For example, a significant number of households could be persuaded to replace their existing boilers more quickly with much more efficient condensing boilers by a combination of a limited grant and the opportunity to spread the costs over a longer period by paying a small levy on their energy bills.

The UK can provide a leading role in delivering the low-carbon economy but this will not be easy. Business must be alert to the opportunities and develop the strategies needed to exploit them. In turn the government must match its moral leadership on climate change with the concrete support that places UK business at the front of the pack.

1. Introduction

Climate change has emerged as one of the dominant issues of our time. An enormous international scientific and political enterprise, in the form of the Intergovernmental Panel on Climate Change (IPPC) and the United Nations Framework Convention on Climate Change (UNFCCC), has been established to evaluate and address the threat. The number of governments around the world putting in place domestic measures to mitigate climate change is increasing. The nature, scale and level of ambition of these policies vary markedly by country and region.

Though other parts of the world are starting to take action, Europe is leading on efforts to address concerns about climate change. In 2007, both the UK and the EU announced targets for ambitious reductions in emissions relative to 1990 levels. The British Government's Climate Change Bill proposes a minimum reduction of 60% by 2050, with an interim target of 26-32% by 2020. The EU is committed to cutting emissions by 20% by 2020, or 30% by 2020 if a matching commitment from major non-EU emitters can be secured.

Meeting targets of this magnitude represents a significant challenge. It will require more efficient use of energy right across the economy and significant 'decarbonisation' of both power generation and road transport. For manufacturers, especially energy-intensive ones, the policies designed to bring about this transformation will probably result in increased regulation and higher energy prices.

However, as well as threats, the transition to a low-carbon economy will provide opportunities for UK manufacturers. EEF has come together with Deloitte Manufacturing Industry Group to look at what they are and how to exploit them. The objectives of the report are to:

- increase awareness amongst manufacturers of the business opportunities associated with the transition to a low-carbon economy and how best to take advantage of them;
- improve understanding amongst policymakers of any barriers preventing opportunities from being exploited and of potential solutions to those barriers; and
- highlight the importance of manufacturing in combating climate change – i.e. manufacturers will play a key role in developing and supplying the products which will help deliver reductions in carbon dioxide emissions.

"There are rapidly expanding markets for low-carbon products and services – the world market for environmental goods and services is projected to grow from $548bn in 2004 to $800bn by 2015."

Ian Pearson, MP, Climate Change and Environment Minister (now Minister of State (Minister for Science and Innovation)[1]

"The environmental challenge of reducing carbon dioxide emissions, in particular, is extremely large. Although this may lead to substantial costs, it is our experience that it can also create correspondingly large opportunities for industry. Competition to seize these opportunities leads to investment by industry in better technologies that can reduce the costs significantly."

Neil Carson, Chief Executive, Johnson Matthey plc[2]

Scope and approach

There is no entirely unambiguous and universally accepted definition of what constitutes the low-carbon economy. However, the general concept is clear – an economy which emits substantially less carbon dioxide or has a lower 'carbon footprint'. The carbon footprint of an activity is a measure of its contribution to greenhouse gas emissions, translated into units of carbon dioxide. Carbon footprints can be measured at a number of levels, including that of an individual, a company or a country. The range of economic activities giving rise, directly or indirectly, to carbon dioxide emissions is vast. Therefore, the coverage of this report is by necessity selective and not comprehensive.

For the purposes of the project, three major areas of the low-carbon economy have been identified:

- **Low-carbon energy:** technologies and systems that reduce the carbon-intensity of energy production (e.g. renewable energy, nuclear power and cleaner fossil fuel based generation).
- **Low-carbon vehicles:** technologies which reduce the carbon footprint of road transport (e.g. biofuels, alternative propulsion systems and 'lightweighting').

1 Shell Springboard Competition National Final, March 2007

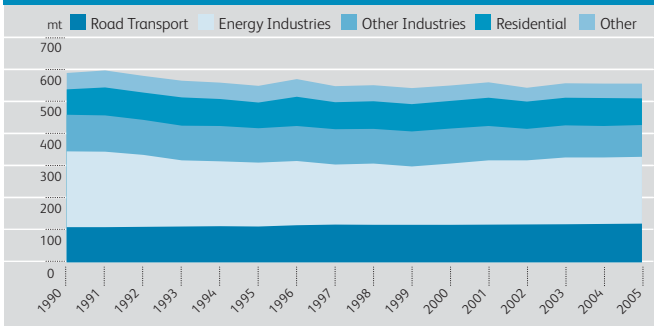
2 From US Select Committee on Energy Independence and Global Warming written evidence "Business Opportunities in a Low-Carbon Economy" Wednesday 10th October 2007

- **Energy efficiency:** a broad range of products which reduce the energy intensity of a given process (e.g. insulation products, industrial automation and energy-efficient appliances).

These product areas are directly relevant to the three largest sources of carbon dioxide emissions in the UK – the energy supply industry, road transport, and industrial/residential sectors (see chart 1 below). The report focuses on identifying major opportunities for manufacturers within these three areas of the economy.

Chart 1 Energy supply and road transport responsible for 60 % of UK carbon dioxide emissions

Carbon dioxide emissions by source: 1990-2005



Source: DEFRA and AEA Energy and Environment

Our findings are based on desk research and face-to-face and telephone interviews with manufacturers, trade associations and other experts. The analysis is primarily qualitative as published data (on markets for emerging products or for products still under development) is by its very nature limited, whether due to commercial sensitivity or the immaturity of the market in question. However, quantitative measures of markets have been included where data is available.

Details of the companies, organisations and individuals who participated in this project and to whom EEF is indebted to for numerous valuable insights are provided at the end of the report.

2. Low-carbon energy

Key points

- The energy industry is the largest source of carbon dioxide emissions in the UK, accounting for 40 % of the total.
- Pressure to meet targets to expand the UK's use of renewable energy and reduce carbon emissions will create significant opportunities for developing a range of sources of low-carbon energy. The most promising for UK industry are in 'clean' coal technologies, offshore wind and marine renewables. However, most of these technologies are currently more expensive than conventional forms of electricity generation and will require financial support for the immediate future.
- Nuclear power has a key role to play in creating a low-carbon energy supply and a new-build programme would also offer significant opportunities for UK manufacturers. However, it is not considered here because the opportunities have already been considered in detail elsewhere.

Clean coal

- Coal is used to generate 40 % of the world's electricity and is forecast to remain the dominant fuel for power generation over the coming decades.
- Two sets of clean coal technologies have particular potential to reduce emissions from coal-fired plant – advanced combustion technologies and carbon capture and storage (CCS).
- The UK's strengths in the power, process and offshore engineering industries, the offshore infrastructure stemming from the petroleum industry and an extensive carbon storage capacity leave it well-positioned to take advantage of any growth in the global market for clean coal technologies.
- UK industry has the capability to supply a number of the major systems, subsystems and components of an advanced coal-fired plant. Areas of particular strength include: supercritical boiler systems, steam turbine generators, gas compressors and air separation units.
- CCS is the removal, transport and storage of the carbon dioxide emissions from a coal plant. UK industry is well-positioned in the major capture-related technologies: gasification, oxyfuel combustion and flue gas scrubbing.
- A number of challenges must be overcome if a CCS industry is to emerge in the UK: scaling-up and integrating the component technologies, financing commercial-scale projects and establishing a dedicated regulatory framework.

Offshore wind

- The UK possesses the best wind energy resources, both onshore and offshore, in Europe.
- Since 2000, UK capacity in offshore wind has been growing by 86 % per year. The Carbon Trust has estimated that UK revenues from offshore wind could hit £2bn per year by 2020, around half of which would come from exports.
- UK manufacturers have had some success in the supply of the structural components (e.g. towers, cable and piles) for wind turbines but far less success in the higher value mechanical and electrical components.
- The potential size of the offshore market and specialist marine engineering capabilities should make the UK an attractive investment location, especially for next-generation turbines designed for offshore deployment.
- UK producers face significant challenges in breaking into well-established global supply chains. The government needs to ensure that obtaining planning consent and connection to the transmission network does not continue to constrain growth in offshore wind capacity.

Marine renewables

- The UK possesses the largest marine energy resource in Europe, around twice as much as any other country. It also has a range of transferable skills and capabilities stemming from the oil and gas, shipbuilding and power generation sectors.
- The Carbon Trust has estimated that the UK could earn annual revenues ranging from £300-900m by 2020 and £600m-£4.2bn by 2050 from marine renewables.
- There are more businesses engaged in the development of devices to harness energy from waves and tidal streams in the UK than in any other country.
- A range of UK manufacturers have world-class capabilities in technologies which could be transferred to the development of marine energy devices. For example, Rolls Royce and Converteam are market leaders in marine propulsion systems.
- The government needs to develop a more coherent strategy if the UK is to realise the opportunities presented

by marine renewables and must review the appropriateness of existing support mechanisms.

Introduction

The energy industry is the largest source of carbon dioxide emissions in the UK. It accounted for 40 % of total emissions in 2005. This makes reducing the carbon emissions associated with energy supply critical to any effort to address climate change.

The UK has ambitious targets to expand its use of renewable energy. Given that half of the renewable energy we use comes from sources that are unlikely to show much growth – hydro-electric power and landfill gas – other forms of renewable energy will need to expand significantly if we are to hit our targets. At the same time the UK will need to draw on other forms of low-carbon energy such as nuclear power and carbon capture and storage (CCS). All have a role to play in the decarbonisation of energy supply and each offers commercial opportunities for UK manufacturers.

We have identified three major areas of opportunity:

- clean coal;
- offshore wind; and
- marine renewables.

A new nuclear build programme would also offer significant opportunities for UK manufacturers, but is not considered here because the opportunities have already been considered in detail elsewhere[3]. For example, a 2006 study by the Nuclear Industry Association (NIA) concluded that UK industry had the capability to supply over 70 % of the content of a new build programme and capture a significant share of overseas business.

Many other areas of opportunity exist for UK manufacturers. One example is the production of PV modules for solar energy arrays. The world's leading manufacturer of PV modules, Sharp, has located its European production facilities in Wales. The plant primarily supplies the European market and is one of only three Sharp production facilities outside of Japan.

Clean coal

Coal is the dominant fuel for electricity generation. In 2005, 40 % of the world's electricity was generated from coal[4]. The world's largest economy, the United States, and its two most populous countries, China and India, have substantial reserves of coal and rely on it for generating the majority of their electricity. However, burning coal to generate electricity is also one of the largest sources of carbon dioxide emissions. If energy consumption, economic growth and efforts to address global warming are to be reconciled, the carbon footprint of coal-fired plant needs to be reduced.

Clean Coal Technology (CCT) refers to a range of technologies which reduce the environmental impact of using coal to generate electricity. Two in particular have the potential to significantly reduce the carbon footprint of coal-fired plant:

- advanced combustion technologies; and
- carbon capture and storage.

Advanced combustion technologies

Advanced combustion technologies increase the efficiency of coal plant, raising the electricity generated per unit of coal. There are two main categories of technology: 'supercritical' plant and 'Integrated Gasification Combined Cycle' (IGCC) plant.

- **Supercritical technology** raises the efficiency of a plant by generating steam at a higher temperature and pressure. The efficiency of traditional plants ranges from 36 % to 39 %. Supercritical plants have efficiencies up to 47 %. More than 240 supercritical plants are in operation worldwide and China is rapidly expanding its fleet[5]. 'Ultra-supercritical' technology holds the potential to raise plant efficiency further, to 50 % and beyond[6].
- **IGCC technology** works by converting coal into gas, purifying that gas to remove pollutants, burning the purified gas to drive a gas turbine and recycling the heated exhaust to drive a steam turbine. IGCC offers efficiencies between 37-43 %, although the potential exists to increase efficiencies to 60 % and beyond[7]. However, the technology is less mature and less widely deployed than supercritical technology in the power industry. Worldwide, there are only four IGCC coal plants currently in operation.

3 See (2006), *The UK capability to deliver a new nuclear build programme*, Nuclear Industry Association and (2005), *An evaluation of the capability and capacity of the UK and global supply chains to support a new nuclear build programme in the UK*, IBM Business Consulting Services.

4 See (2007), *Key World Energy Statistics*, International Energy Agency

5 See www.worldcoal.org

6 (2005), *Post Note: Cleaner Coal*, Parliamentary Office of Science and Technology

7 (2005), *Post Note: Cleaner Coal*, Parliamentary Office of Science and Technology

Carbon capture and storage (CCS)

CCS is the removal, transport and storage of the carbon dioxide emissions from a coal plant. Carbon dioxide is 'captured' either before or after combustion, compressed for transportation (e.g. by pipeline) and injected into a storage site in a suitable geological formation (e.g. a depleted oil or gas field or a saline aquifer). There are three main approaches to capture – pre-combustion, post-combustion and oxyfuel.

- **Pre-combustion capture** is the removal of the carbon contained in coal prior to its combustion. Coal is 'gasified' to produce a 'synthesis gas' comprising carbon monoxide and hydrogen. The synthesis gas is treated with steam to convert the carbon monoxide into carbon dioxide which in turn is separated-out using a solvent or membrane.

- **Post-combustion capture** is the removal of carbon dioxide from the flue gas emitted after the combustion of coal in a power plant. The carbon dioxide is separated from the exhaust stream using a chemical solvent, typically amine-based.

- **Oxyfuel** is a variant of post-combustion capture in which coal is first burnt in an oxygen-rich environment to facilitate the subsequent removal of carbon dioxide from the flue gas.

Potential market

The size of the potential market for clean coal technologies is vast. Global warming will remain high on the international political agenda and coal a major source of energy worldwide for decades to come. Projections from a number of organisations illustrate the likely extent of this growth:

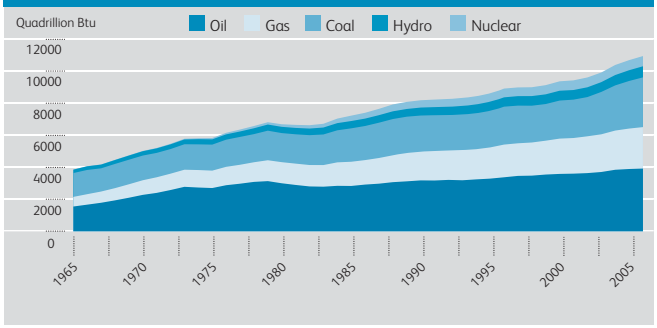
- The US Energy Information Administration (EIA) forecasts that coal will be the fastest growing source of energy over the next few decades. It predicts that between 2007 and 2030, global energy use will increase by some 45 % and that a third of that will be fuelled by coal.

- According to the International Energy Agency (IEA), over 1400 GW of new coal-fired generation capacity will be needed worldwide by 2030 to replace retiring plant and meet rising demand. The Advanced Power Generation Technology Forum (APGTF) values this new capacity at $1400bn in 2004 prices[8].

- The IEA estimates that CCS will need to be installed on the equivalent of 630 coal-fired power plants by 2030 in order to meet global carbon dioxide emissions reduction targets[9]. This could translate into a market worth approximately $40bn per year.

Chart 2 Coal to remain major part of global energy mix in decades ahead

Global energy use by fuel type



Source: Energy Information Administration (USA)

Opportunities for UK industry

The combination of strengths in relevant industries, offshore infrastructure stemming from the petroleum industry and extensive geological storage capacity make the UK well positioned to take advantage of any growth in the global market for clean coal technologies.

The UK has a world-class manufacturing, R&D and skill base in power, process and offshore engineering. These industries form the basis of the supply of equipment, technologies and skills for clean coal technologies.

The infrastructure (e.g. terminals and pipelines) and depleted fields of the North Sea oil and gas industry give the UK a competitive advantage in developing the foundations for a CCS system. In particular, the maturity of the UK continental shelf provides a range of accessible, well-mapped and well-understood depleted fields for the storage of carbon dioxide.

The opportunities for UK industry fall into two main categories:

- the supply of capital goods for advanced plant; and

- the licensing of gasification and capture technologies to third parties.

Supply of capital goods for advanced plant

Significant opportunities exist now and in the future for UK suppliers of capital goods to the power generation industry. The UK has a strong manufacturing and R&D base in the

8 (2004), *A vision for Clean Fossil Fuel Power Generation*, UK Advanced Power Generation Technology Forum

9 Announcement made at the November 2007 G8 Workshop in Calgary

sector. A range of transnational companies have significant production facilities and research operations in the UK.

UK industry has the capability to supply a number of the major systems, subsystems and components of an advanced coal-fired plant. Areas of particular strength include: supercritical boiler systems, steam turbine generators, gas compressors, air separation units, heat exchanger systems, fans, pumps/valves and pipework. In addition, many companies enhance their product offering with high value-added system integration services.

Beginning with air separation unit manufacturer Air Products below, this report profiles manufacturers active in the low-carbon economy.

Air Products

Air Products plays an active role as technology provider to a number of collaborative research programmes addressing the challenges of low-carbon electricity production based on gasification and oxy-fuel processes. It also works closely with developers of commercial-scale CCS projects in order to optimise technology choices.

From its origins in cryogenic air separation technology for the production of oxygen and nitrogen, Air Products has grown to become a global supplier of industrial gases and equipment based on cryogenic, adsorption and membrane separation technologies. It also the world's largest producer of merchant hydrogen.

The company continues to pursue programmes to broaden and enhance its offerings targeted to multiple industrial sectors including refineries, petrochemicals and steel – and, in recent years, to develop offerings to the low-carbon energy sector. Key contributions to this developing sector are: world-class design, manufacturing and operations capabilities for large oxygen and hydrogen production systems, knowledge and experience in the development and deployment of advanced CO2 separation and purification technologies, experience in the safe handling and distribution of gaseous products.

The UK plays a key role in Air Products' pursuit of opportunities in low-carbon energy. Not only are key R&D functions located there, but the UK also hosts large elements of the company's engineering activity. In addition, Air Products' manufacturing facility in North Wales exports oxygen plants to customers globally.

In the 1990s, UK industry captured approximately 12 % of the global market for power plant equipment[10]. There are opportunities to generate significant export revenues from the supply of equipment for advanced coal plant equipment, both new-build and retrofit (e.g. 'repowering' plant with supercritical boilers and steam turbines). In the rapidly industrialising parts of the developing world, there are significant opportunities for UK companies to form partnerships with lower-cost local manufacturers and provide them with production licenses. For example, the Harbin Boiler Company is a leading supplier of supercritical boilers, under license from Doosan Babcock, to Chinese utilities.

Doosan Babcock Energy

Doosan Babcock is a multi-specialist energy services company operating in the thermal power, nuclear, petrochemical, oil and gas and pharmaceutical industries. The company has been building thermal power plants since the 1890s and had a turnover of £430m in 2006.

The company is a major international steam generation OEM and a leading supplier of clean coal technology world-wide.

Doosan Babcock has completed projects representing more than 150,000 MW installed capacity worldwide, including over 23,000 MW of supercritical coal technology in the past two years. The company is active in the world's largest coal generation markets.

In China, Doosan Babcock collaborated with the Harbin Boiler Company to secure the largest percentage of new power plant orders globally in 2004. The plants commissioned emitted 20-30 % less CO2 than conventional plants.

The company is a leading developer of carbon dioxide capture technology for pulverised coal-fired power plants.

Licensing of gasification and capture technologies

Significant opportunities could emerge in the near future for UK suppliers of gasification and capture technologies should CCS take off around the world. UK companies, and the UK operations of a number of transnational companies, own proprietary rights to market-leading capture-related technologies. These include gasification technologies (e.g. Shell and Air Products), oxyfuel-combustion technologies (e.g. Air Products and BOC) and flue gas scrubbing technologies (e.g. Doosan Babcock and Fluor). Demand for

10 (2004), *A vision for Clean Fossil Fuel Power Generation*, UK Advanced Power Generation Technology Forum

CCS plant around the world could provide these companies with major opportunities to license their technologies to local utilities and developers.

CCS-related services

Whilst the focus of this report is the opportunity in technology development and manufacturing, a strong CCS market would also provide significant opportunities for UK industry to provide a range of services associated with CCS such as engineering design, process engineering and maintenance of offshore infrastructure.

Barriers for UK industry

The market for advanced combustion coal plant equipment and technologies, especially those for supercritical plant, is well-established and growing. However, the supply of equipment and technologies specifically for CCS is a longer-term opportunity. A number of barriers must be overcome if a CCS industry is to emerge in the UK:

- scale-up and integration of technologies;
- cost; and
- lack of a full regulatory framework.

Scale-up and integration of technologies

The feasibility of each individual element of CCS technology has been proven in a range of existing industrial applications. However, the integration of those processes into a robust system of sufficient scale for routine application in the power generation sector still requires research and demonstration.

In November 2007, the UK Government announced details of a long-awaited CCS demonstration programme under which a competition will be held and the winning project will receive funding to demonstrate the full-scale application of CCS to power generation. However, the announcement also stipulated that the competition would only be open to post-combustion projects. The programme is welcome because commercial scale demonstration of the end-to-end process is vital for building confidence in CCS and reducing its cost.

However, restricting entry to post-combustion projects runs the risk of missing out on opportunities to develop pre-combustion projects in the UK. A number of developers had already invested significant sums in pre-combustion projects on the basis that they would be given equal consideration for government funding. There is a danger that these projects might be terminated and investment in pre-combustion projects refocused overseas.

Cost

At its current stage of technological development, CCS is not economically viable without financial support. The capture, transport and storage processes would add significantly to the cost of generating electricity from coal. An IPCC study has estimated the premium to be between $18/MWh and $34/MWh for a solid fuel plant and between $9/MWh and $32/MWh for an IGCC plant[11]. The energy consumed as part of the capture process is the main factor behind the premium. Research carried out by EEF suggests that a sustained carbon price of at least €40/tCO2 would be required to make CCS commercially viable.

The principal mechanism for carbon pricing in Europe is the EU ETS. The scheme is currently generating prices around €20/tCO2, has displayed considerable volatility and its future is not clear beyond 2012. Until such time as the EU ETS delivers a sufficiently attractive, stable and long-term price signal for investors it is unlikely to facilitate the expansion of CCS. As a result, there is a strong case for introducing additional financial incentives for CCS. Early projects, which carry a 'first of a kind' risk and a disproportionately high share of infrastructure costs, will be particularly dependent on support.

Lack of full regulatory framework

International law is in the process of being changed to allow the storage of carbon dioxide under the seabed. The necessary amendments have been made to the London Protocol and it is anticipated that those proposed to the OSPAR Convention will be ratified in the near future.

As well as amendments to international law, a clear, comprehensive and long-term regulatory framework needs to be established to facilitate the emergence of CCS. Amongst the key elements required are an internationally accepted methodology for carbon dioxide accounting, agreement over the treatment of CCS under the EU ETS, a consenting regime for CCS assets and clarity over the level of private sector liability for long-term storage of carbon dioxide.

The establishment of a clear, comprehensive and long-term regulatory framework is also vital if offshore assets (e.g. depleted fields, pipelines and platforms) close to decommissioning are to be retained and, perhaps,

11 (2005), *Special Report on Carbon Dioxide Capture and Storage*, Intergovernmental Panel on Climate Change

eventually recycled for use as part of a CCS infrastructure. With the 2008 Energy Bill the government has announced the establishment of a regulatory framework to enable private sector investment in CCS. It is vital that this delivers the clarity that the industry requires.

Offshore wind

"The UK has some of the best offshore wind resource in the world, a long history of design, installation and operational expertise in the offshore environment and the skills and manufacturing capability to transfer to this exciting new sector."

"The UK is now the number one location for investment in offshore wind in the world and next year we will overtake Denmark as the country with the most offshore wind capacity. I want to ensure the UK remains one of the best places for renewable business."

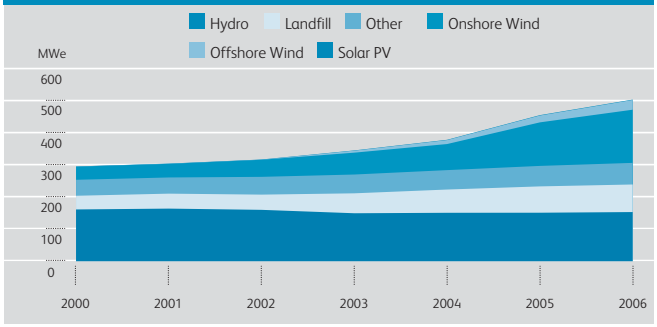
Rt. Hon. John Hutton, MP, Secretary of State, Department for Business Enterprise and Regulatory Reform[12]

The UK possesses the best wind energy resources, both onshore and offshore, in Europe. The onshore physical resource has been estimated at 40TWh per year and the offshore resource is estimated to be even greater at between 67TWh and 1,000TWh per year[13]. Given that annual UK consumption of electricity is currently around 350TWh, this represents a very significant resource.

Since 2000, wind has been the main driver of the UK's growth in renewable energy. Between 2000 and 2006, renewable generation capacity has increased by approximately 2 GW, and 1.5 GW of that has come from wind. Offshore wind saw the greatest annual growth rate over the period at 86%, with installed capacity expanding from less than 5 MW to over 300 MW. Onshore wind and solar capacity grew at 22% and 26% respectively. Landfill gas capacity increased more slowly at a rate of 11%, reflecting the greater maturity of that energy source, whilst hydro capacity actually declined fractionally at a rate of 1%.

Chart 3 Wind main driver of growth in renewable energy in the UK

Installed Capabilty



Source: BERR

Potential Market

Given the relative immaturity of the offshore wind market, both globally and in the UK, market projections are limited and, to a degree, speculative. However, existing projections forecast significant opportunities both in the UK and for UK businesses. For example, work commissioned by Renewables East has forecast that the UK offshore wind market will become the largest in the world by the end of this decade, with annual capital expenditure exceeding £1bn from 2009[14]. Taking a slightly longer perspective and looking at opportunities for UK business, work conducted by the Carbon Trust has estimated that the economic opportunity for the UK could be of the order of £2bn per annum by 2020, around half of which would come from export business[15].

Offshore wind is not currently economically viable without financial support. At present, it is a relatively expensive means of generating electricity. Table 1 provides indicative costs for a number of the most common technologies for electricity generation[16].

Table 1: Cost of generating electricity by energy source

Energy Source	Cost (£/MWh)
CCGT Gas	23.1 – 34.5
OCGT Gas	32.7 – 50.6
Nuclear PWR	32.5
Conventional Coal	32.6 – 41.6
IGCC Coal	35.6 – 43.1
Onshore Wind	54.1 – 56.4
Offshore Wind	69.3 – 71.2

Source: EEF

12 European Energy Industry Conference Berlin December 2007

13 See (2007), *Energy Markets Outlook*, Department for Business, Enterprise and Regulatory Reform

14 See Douglas-Westwood ltd and ODE ltd (2005), *Scroby Sands – Supply Chain Analysis*, Renewables East

15 See L.E.K Consulting (2006), *Policy Frameworks for Renewables*, Carbon Trust

16 The costs are based on research carried out for: (2005), *Sustainable Energy: A Long-term Strategy for the UK*, EEF. Increases in fuel and construction costs since then mean that generation costs may now be above the upper band but are unlikely to have affected significantly the relative costs shown in the table

As a result, the offshore wind market, and hence opportunities for UK industry, will remain dependent on policy support for the immediate future. Substantial support and incentives are provided for offshore wind in the UK through the Renewables Obligation (RO) – a legal obligation on utilities to source a specified and rising proportion of the electricity they provide to their customers from renewable sources. In December 2007, the government underlined its long-term support with the launch of a Strategic Environmental Assessment (SEA) of UK waters. The aim of the SEA will be to assess the government plans to install up to 25GW of offshore wind capacity by 2020[17].

Opportunities for UK industry

Experience of developing North Sea oil and gas assets provides UK industry with engineering skills and capabilities which can be applied to offshore wind. The significant resource, rapidly growing market and transferable capabilities translate into a number of potential business opportunities for the UK. In particular:

- increasing UK content in current generation turbines
- developing systems and components for next generation turbines; and
- associated products and services.

Increasing UK content in current generation turbines

UK manufacturing has a proven capacity to make a major contribution to the offshore wind market. Evidence of this is provided by Scroby Sands, one of the first major offshore winds farms in Britain, in which UK-produced goods accounted for 43 % of the value of the manufacturing element of the project. The table below summarises the UK content by major component:

Table 2: Significant UK content in Scroby Sands wind farm

Component	Value (%)	UK Share (%)
Nacelles	41	1 %
Piles	24	100 %
Blades	15	0 %
Towers	12	98 %
Cables	7	100 %
Indirect Costs	1	8 %
Overall	**100%**	**43%**

Source: Douglas-Westwood Ltd and ODE Ltd

Scroby Sands highlights some of the strengths, weaknesses and potential of the UK offshore wind supply chain. Of the major components, UK suppliers monopolised provision of towers, piles and cables. The challenge for UK manufacturers of these goods is to consistently match the level of contribution achieved at Scroby Sands.

UK contribution to the blades and nacelles[18], two of the highest value-added elements in a turbine, was extremely limited at Scroby Sands. The nacelle and its contents are the single most valuable element, housing the electrics (e.g. the generator and power converter), drivetrain (e.g. the gears and hydraulics) and rotor hub (e.g. castings and control systems). Increasing the UK content in the mechanical and electrical components to match that achieved in structural elements is a major challenge and opportunity for UK manufacturers.

A notable UK success story is Converteam, which has used its expertise in power conversion equipment to carve out a position as the largest UK supplier to the global wind industry and establish itself as a market leader in converters and power electronics for wind turbines.

Converteam

Converteam has been actively involved in the renewable energy business since the early 1990s. Over 300 dedicated staff work within Converteam UK to develop advanced technology and solutions for customers. With an annual turnover of €100m for the renewables business alone, Converteam continuously invests in research and development to advance this increasingly prominent and significant market.

Converteam are currently the UK's biggest exporter to the wind industry. Their 'direct-drive' generators operate at the speed of the wind turbine's rotor, halving the number of components required in the nacelle at the top of a wind tower. This also enables compliance with the very latest grid codes.

Converteam has exported over 2500 MW of power conversion equipment to the industry, which can be found in turbines in the most recent offshore wind farms at Burbo Bank in Liverpool Bay and at Lillgrund in the Oresund Sound, and also onshore at the world's largest wind farm, the Horse Hollow Wind Energy Centre in Texas.

17 10 December 2007, *Plans for Major Expansion of Offshore Wind*, Department for Business Enterprise and Regulatory Reform

18 The nacelle is the structure at the top of the tower housing the rotor shaft, gearbox and generator and to which the blades are attached

However, the share secured by UK manufacturers in Scroby Sands is not representative of most offshore projects to date and could be difficult to achieve in future developments. The UK company which supplied the cables for Scroby Sands is no longer in business and overseas tower OEMs are increasingly delivering their products direct to the UK. The challenge for UK industry is to develop joint ventures with overseas companies.

Opportunities also exist for the application of specialist technologies developed in other industries to wind turbines. For example, Torotrak, a UK-based market leader in infinitely variable transmission (IVT) systems for the automotive and off-highway vehicle industries, has identified wind turbines as a potential market for its products. Similarly, SSD Drives, a UK-based manufacturer of industrial automation equipment, is exploring the wind industry as a potential market for its motor control systems.

Developing systems and components for next generation turbines

The challenging nature of the offshore environment is providing a stimulus for innovation in the wind industry. Corrosion of offshore turbines has proved greater than expected, resulting in lower output and higher maintenance costs than anticipated. Gearbox operation in particular has proved vulnerable to corrosion.

The industry is developing the next generation of wind turbines – so-called 'direct-drive' turbines. Essentially, these turbines function without the need for a gearbox or drivetrain – minimising the requirement for high-speed mechanical and electrical components. Therefore, direct-drive turbines would have a significant operational advantage offshore compared to the current generation.

Companies active in this area include major overseas turbine manufacturers, but also specialist suppliers such as Converteam. The latter's UK operations have developed a direct-drive generator which removes the need for gearboxes and halves the drivetrain component requirements.

Direct-drive turbines are low-speed and high-torque (i.e. rotational force), making them very large. Use of superconducting materials offers the possibility of reducing their size. Traditionally, High Temperature Superconducting (HTS) products have been expensive. However, a new generation of low cost HTS wire is being developed which will make it a more realistic option for use in wind turbines. Converteam, with the support of the BERR Technology Programme, is undertaking a project to design a full-size direct-drive HTS generator for wind turbines. Manufacture and testing of a scale model generator is currently targeted for 2008. Success would open up the possibility of ultra-high-rated (e.g. 8 MW) turbines for use offshore.

The potential size of the UK offshore wind market creates significant opportunities for UK manufacturers and technology businesses to contribute to the development of the next generation of turbines. The scaling-up and refining of components for use in these turbines should offer a number of potential niche markets for UK businesses.

Associated products and services

In addition to the development and manufacture of turbine components, significant opportunities could exist for UK industry in the supply of related products and services. These include deployment vessels, construction of offshore substations and operational services.

Barriers for UK industry

Two major barriers will need to be overcome for UK manufacturers to take advantage of opportunities in the offshore wind market:

- a highly consolidated industry with established supply chains; and
- obtaining planning consent and grid connection is currently problematic.

Consolidated industry with established supply chains

The production of large-scale wind turbines is a highly consolidated market and dominated by German, Danish, Spanish and American manufacturers. The top ten manufacturers account for over 90 % of the market and the top four for almost 75 %. In 2005, the top four global suppliers were Denmark's Vestas (23 %), America's GE (18 %), Germany's Enercon (13 %) and Spain's Gamesa (13 %)[19].

Consolidation also exists in the manufacture of some of the major components. Two companies, Winergy (40 %) and Hansen Transmission (30 %), account for almost three-quarters of the market for gearboxes. Market consolidation is being strengthened further by the trend towards vertical integration in the industry, as represented by the recent acquisition of gearbox manufacturer Hansen Transmisson by Indian turbine manufacturer Suzlon.

In addition, turbine manufacturers typically have well-established supply chains, in which trusted relationships

19 (2007), In the Black: *The Growth of the Low Carbon Economy*, The Climate Group

have been built up over several years, and tend to focus their procurement resources close to their existing production facilities.

The combination of a highly-consolidated industry, a trend towards vertical integration and well-established component supply chains represent a significant, but not insuperable, barrier to entry for UK manufacturers.

The supply chains for next-generation turbines are not yet fully established. However, concerns exist that UK suppliers may not be able to make the required investments and level of commitment to compete with overseas suppliers. For example, Converteam has already encountered difficulties in sourcing components (e.g. large castings) for these systems from UK suppliers. Ultimately, the ability of UK suppliers to respond quickly to the rapid growth anticipated in the offshore wind industry could determine whether or not new manufacturing facilities are located in the UK.

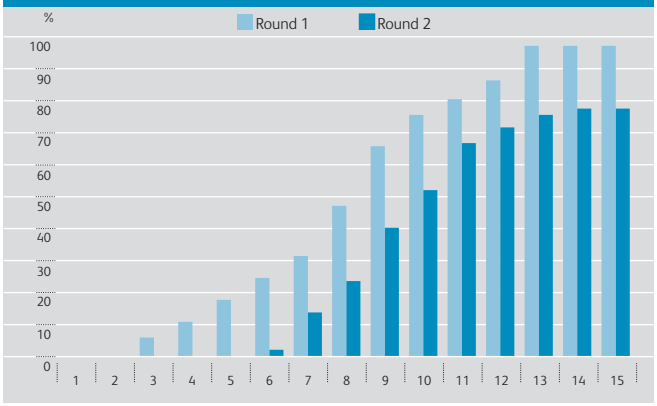
Planning consent and grid connection

Obtaining planning consent and connection to the transmission network has proved a major constraint on the growth in offshore wind capacity in the UK. According to the British Wind Energy Association (BWEA), as of November 2007, more than 2000 MW of offshore capacity was in the planning process. These statistics reflect both the interest in the UK offshore wind market and the slow pace of the planning process.

To date, the Crown Estate, owner of the seabed in UK territorial waters, has issued rights to develop offshore wind farms in two tranches, 'Round 1' and 'Round 2'. The experience of those farms already built and developers' expectations of those currently within the system is one of long lead-times. It is expected to take about eight years before half of the capacity awarded under Round 1 is installed and closer to a decade for Round 2.

Chart 4 Lead times for offshore wind farms remain considerable

% capacity installed by years from award



Source: BWEA

In November 2007, the government introduced a Planning Bill designed to address elements within the planning regime which act as a barrier to energy projects. The Bill aims to introduce a regime engendering more timely, predictable and transparent decisions for major energy infrastructure projects. The BWEA expects the lead-time for installing offshore farms to fall once the reforms have been implemented.

However, it remains to be seen how far these reforms will actually go in addressing the issues faced by the wind industry. Currently, it is characterised by a multiplicity of smaller projects as opposed to the fewer, larger scale projects typical of thermal-generation projects (e.g. fossil fuel and nuclear plant).

As well as planning, the need to upgrade and, in some instances extend, the transmission network to accommodate additional wind energy capacity could also act as a barrier to the pace of deployment of offshore wind farms.

However, significant investments in Britain's electricity transmission network are scheduled over the next few years. The energy transportation companies agree capital expenditure requirements for five-year periods with energy market regulator Ofgem under a regulatory process called 'price control'. In the most recent price control, Ofgem authorised an unprecedented increase in investment in Britain's gas and electricity transmission systems for the period 2007 to 2012. The £5.1bn investment planned over the period represents a 100% increase from the previous five-year period and includes substantial work designed to accommodate growth in renewable energy capacity.

Marine renewables

Another major area of opportunity for UK industry is 'marine energy' or 'marine renewables' – a range of technologies designed to capture the energy embodied in the waves, tides and thermal differences of the oceans. Two forms in particular, 'wave energy' and 'tidal stream energy', offer some of the most promising opportunities for the UK.

Wave energy is the generation of electricity from the movement of waves. Waves are formed by the wind dragging water across the ocean. The stronger the wind and the greater the distance across which it blows, the larger the waves and the more energy released.

Tidal stream energy is the generation of electricity from tidal flows. Tidal 'streams' are fast-moving currents generated by water flowing between areas of differing tidal height and are most powerful where they are funnelled by landforms (e.g. around headlands and between islands).

Potential market

The UK possesses the best marine energy resource in Europe, around twice as much as any other country. Approximately 35 % of the total European wave resource and 50 % of the total tidal stream resource are located in British waters. The indented and exposed Atlantic coastlines of south-west and north-west Britain provide many sites with powerful waves and tidal streams. The UK's practically accessible wave energy resource has been estimated at between 50 and 60 TWh per year and the tidal stream energy resource between 18 and 36 TWh per year. Based on these resource estimates, marine energy is considered capable of meeting between 15 % and 25 % of UK electricity demand[20].

In addition, UK industry has a range of transferable skills and capabilities stemming from the oil and gas, shipbuilding and power generation sectors. These include offshore drilling, installation of subsea cables and the design and manufacture of floating offshore platforms. The combination of a generous endowment of natural resources and transferable capabilities suggests the potential for significant business opportunities for the UK.

The marine energy industry is at a crucial stage, on the cusp of transition from demonstration to commercialisation. Several large-scale demonstrators have been installed, extensively tested and operated by British companies. The industry is moving from one dominated by start-ups, specialist equipment manufacturers and university engineering departments, to one with increasing involvement from major utilities and major industrial manufacturers. Examples of this trend include the recent acquisition of Wavegen by Voith Siemens Hydro, E.ON's collaboration with Ocean Prospect to trial the Pelamis device in Cornwall, and Scottish and Southern Energy's involvement in developing the Neptune tidal stream generator. However, no commercial projects have been completed to date, although several are in the pipeline.

Considerable uncertainty remains around the cost of generating electricity from marine energy devices[21]. Work for the Carbon Trust has put the cost of wave power from between 12p/kWh and 44p/kWh and the cost of tidal stream power from between 9p/kWh and 18p/kWh. However, it is likely that these figures overestimate the long-run cost of marine energy. Inferring the costs of tomorrow's commercial devices from today's prototypes ignores the potential for economies of scale and design improvements.

As a result, market forecasts are largely speculative. Nevertheless, the Carbon Trust has estimated that the UK could earn annual revenues ranging from £300m-900m by 2020 and £600m-£4.2bn by 2050 from marine renewable[22].

Opportunities for UK industry

The UK pioneered research into marine energy technology in the 1970s and 1980s. Now, the UK has the opportunity to develop a domestic industry capable of designing, manufacturing, installing and operating devices for an emerging global market in marine energy. The most significant opportunities for UK industry are to develop and manufacture:

- industry standard devices; and
- specialist products for niche markets.

Opportunity to develop industry standard devices

The UK has established itself as an early leader in marine renewable energy. There are more businesses engaged in the development of devices to harness energy from waves and tidal streams in the UK than in any other country. There are over 30 device-developers headquartered in the UK. This compares to approximately 15 in the rest of Europe and 20 elsewhere in the world. Currently, there is a range of competing wave and tidal stream energy device technologies. However, the 'winning' device designs have not yet emerged.

In addition, the UK has unrivalled grid-connected demonstration facilities. These include the European Marine Energy Centre (EMEC) based in Stromness (Orkney) and the

20 See (2006), *Future Marine Energy*, Carbon Trust; L.E.K Consulting (2006), Policy Frameworks for Renewables, Carbon Trust and (2007) *Energy Markets Outlook*, Department for Business, Enterprise and Regulatory Reform

21 See (2006), *Future Marine Energy*, Carbon Trust

22 See L.E.K Consulting (2006), *Policy Frameworks for Renewables*, Carbon Trust

Wave Hub project off the Cornish coast. EMEC is a purpose-built, open-sea test facility providing multiple berths within which devices can be tested in a wide range of wave and tidal conditions. In September 2007, the Wave Hub project received planning permission. Scheduled for completion in 2009, the project will provide an onshore substation connected to electrical equipment on the seabed via a sub-sea cable. Companies will be granted 5-10 year leases to test devices on an unprecedented scale (a combined capacity of 20 MW) and feed electricity into the transmission network.

The major opportunity for the UK lies in exploiting its early advantage in marine renewables to develop 'industry standard' devices – the wave energy and tidal stream devices which will become mass-produced and replicated across the industry in the same way that the three-blade turbine has in the wind industry.

Amongst the competing technologies, two types of wave energy device and one type of tidal stream energy device appear to be leading the market:

- **Oscillating water columns (wave):** the movement of the waves is used to force water in and out of an opening in a tubular chamber. The resultant rise and fall of water within the chamber forces air back and forth through an air turbine to produce power. Wavegen's Limpet and Osprey are examples of this type of device.

- **Surface-following devices (wave):** consist of a series of semi-submerged cylindrical structures that are hinged together and rest on the ocean surface. The wave-induced motion of the joints in the structure is used to produce power. The Pelamis Wave Energy converter is an example of this type of device; and

- **Axial turbines (tidal stream):** turbines, similar to submerged wind turbines, are placed in a tidal stream. As water flows past, the turbines turn and produce power. Marine Current Turbines' Seaflow and SeaGen are examples of this type of device.

With the recent award of their first commercial contracts, Wavegen, Pelamis Wave Power and Marine Current Turbines are in the process of establishing industrial partners to manufacture their devices. Manufacturers have a unique opportunity to become the suppliers of choice for UK-based device developers and cement their position within the embryonic supply chain emerging around them.

A range of UK manufacturers have well-established, world-class capabilities in technology which could be transferred to the marine energy devices. For example, Rolls Royce and Converteam are market leaders in marine propulsion systems.

Opportunity to develop specialist products for niche markets

Opportunities also exist for UK industry in the development and manufacture of niche marine energy products. These include 'off-grid' devices and smaller-scale devices integrated into infrastructure.

Off-grid devices hold the promise of opening up markets in more remote parts of the world where there is limited energy distribution infrastructure. By incorporating energy storage and self-start functions into marine energy devices, they can be deployed in situations where the lack of transmission and distribution infrastructure would make grid-connected devices impractical.

Small-scale marine energy devices designed to be incorporated into coastal or offshore infrastructure offer significant advantages. They can increase the environmental credentials of infrastructure projects from a planner's perspective and improve the economics of marine energy devices. Scotland's Wavegen is a pioneer in this field and has recently won a contract in Spain to incorporate wave energy devices into a breakwater.

Wavegen

Wavegen is a wave energy company based in Scotland and is a wholly-owned subsidiary of Voith Siemens Hydro Power Generation. In 2000 Wavegen became the first company to connect a commercial-scale wave energy plant to the grid.

The company technology is based on the Oscillating Water Column (OWC) with 'air turbine power take-off technology'. This technology has been demonstrated at full scale with the successful grid-connected Limpet plant on the island of Islay. This plant is currently being used as a test bed for the company's products and has given Wavegen unrivalled experience of wave plant operation.

Wavegen is undertaking a contract in Spain for the Basque Energy Board to supply the mechanical and electrical equipment for a wave energy plant in a breakwater at the port of Mutriku in the Basque country. The plant will consist of 16 OWCs each driving an individual turbo-generator. The plant will supply 'green electricity' to around 250 households with a rated power of nearly 300 kW. The plant will be commissioned in the winter of 2008/2009.

Wavegen is working with npower renewables on feasibility and preliminary engineering for a 4MW near-shore project off the Scottish Western Isles. This is planned for commissioning in 2011.

Large-scale oxygen plants manufactured in Wales and bound for Oryx GTL project in Qatar

Construction of wave energy plant, Mutriku, Spain

Barriers for UK industry

Major obstacles exist to the development of a robust marine energy market and industry in the UK. In particular, three key barriers will need to be overcome for the opportunities described above to be realised:

- financing the commercialisation of technology;
- obtaining planning consent and grid connection; and
- limited public support for energy-related R&D.

Financing commercialisation of technology

A strong UK market for marine energy will support the development of a domestic industry. The UK must establish itself as the favoured location for the deployment and manufacture of marine energy systems, not just their testing and development.

The early stage of development and uncertainty around the cost of marine-based electricity generation means that public sector financial support will have an important role in bringing about its commercialisation. Denmark, Spain and Germany provide examples of how public support for an emerging source of renewable energy can deliver significant economic benefits over time. These countries were amongst the first to introduce clear, substantial and long-term financial support for wind energy in the form of 'feed-in tariffs'. Through this mechanism, wind farms were guaranteed a premium rate for each unit of electricity produced for fixed period of time, typically ten to twenty years. This provided potential investors with a degree of certainty over returns and was a significant factor behind the emergence of major turbine manufacturing industries in each of these countries.

The two policy mechanisms in the UK designed to support commercialisation of marine energy are in need of reform. Elements of these policies are barriers to the development of wave and tidal stream energy.

The Renewables Obligation (RO)

The RO is a requirement on licensed electricity suppliers to source a specific and annually-increasing percentage of the electricity they supply from eligible renewable sources. Generators are issued with tradeable certificates for each unit of renewable electricity produced. The supply of, and demand for, certificates generates a 'market' price for renewable energy.

The price of certificates is variable and can be difficult to forecast accurately. This is unattractive for investors in marine energy. The combination of uncertainty over both the cost of generation and the value of certificates means that investors are likely to either invest in more established renewable technologies or charge a significant premium for financing marine energy projects.

Reforms proposed in the 2008 Energy Bill would increase support for marine energy by providing multiple certificates to 'emerging' technologies and fix a limited element of the value of certificates. The reforms are welcome, but will not resolve the fundamental issue of uncertainty over the value of certificates.

The Marine Renewables Deployment Fund (MRDF)

The MRDF is a £50m government fund, set up in 2005, designed to support the commercialisation of wave and tidal stream energy. The majority of the fund, £42m, is ring-fenced for capital grants and revenue support for technologies for which the R&D has been completed. To apply for funding under the scheme, developers must have demonstrated full-scale versions of their devices in a range of sea conditions for three months continuously or six months in any 12-month period. Awards per project are capped at £9m.

Sections of the marine energy community view the eligibility criteria for MRDF funding as too strict. To date, there have only been two applications for funding under the MRDF, both of which have been unsuccessful. This begs the question as to whether the MRDF is the right form of support for the marine energy industry given its current stage of development, and whether the funds would be better deployed in helping developers reduce the cost of their devices through R&D.

Failure to address the deficiencies in the existing funding arrangements for marine energy could see operations currently based in the UK shift to more supportive countries. For comparison, Portugal provides support for marine energy through a 'feed-in tariff' which guarantees a fixed premium price per unit of electricity generated for a period of twelve years. The first commercial wave farm, comprising three 750kw devices designed by Scotland's Pelamis Wave Power, is scheduled to be become operational in Portugal in the near future.

Obtaining planning consent and grid connection

In the longer-term, the connection of substantial wave and tidal stream generation to the transmission and distribution networks will represent a significant challenge. The most promising marine energy resources, both wave and tidal stream, tend to be located in the remoter parts of the UK

where electricity transmission and distribution infrastructure is currently relatively limited – e.g. northern and western Scotland. Coupled with the demands already being placed on the transmission network in these areas by increasing levels of wind generation, infrastructure constraints could significantly slow the deployment of marine renewables[23]. However, south-west England, with its combination of good marine energy resources and spare transmission capacity, could offer an alternative location for the early deployment of wave and tidal stream energy projects.

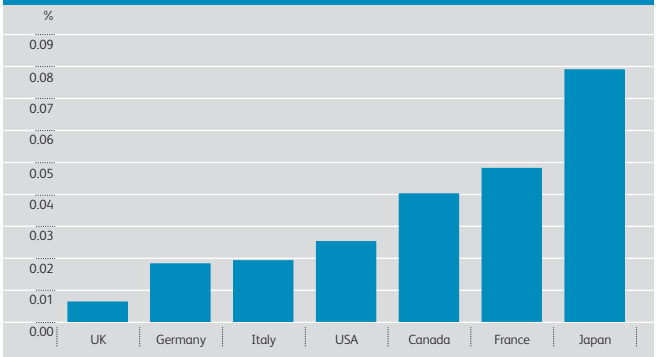
The planning process will also have a key influence on the availability of connection capacity. Major upgrades, reinforcements and extensions to the transmission network are subject to rigorous and often lengthy planning procedures. A prime example of these problems is the Beauly-Denny upgrade between Inverness and Falkirk. A planning application for the project was a submitted in 2005. Uncertainty over the length of the planning inquiry means that completion of the upgrade could be any time between 2010 and 2015.

Limited support for energy R&D

Public funding for R&D in emerging technologies, such as marine renewables, can play a significant role in accelerating its development deployment. However, public funding for energy-related R&D in the UK is very low compared to other industrialised nations. In 2005, the UK contributed the lowest share of GDP to energy-related R&D amongst any of the G7 nations.

Chart 5 UK lags behind rest of G7 for R&D support

Public energy R&D budget as % of GDP



Source: IEA

The establishment of the Energy Technologies Institute (ETI) is welcome. Government has announced that it will allocate matching funds of up £50m per year to energy-related R&D via the ETI. However, the additional funding will still leave the UK behind its major competitors.

23 (2006), *The Path to Power*, British Wind Energy Association

3. Low-carbon vehicles

Key points

- Road transport is the second largest emitter of carbon dioxide in the UK and is one of the few major sectors of the economy in which emissions are rising.
- A range of vehicle technologies and fuels exist which could lower the carbon footprint of road transport. Two major areas of opportunity for UK manufacturers are in internal combustion engines and hybrid and electric vehicles.

Internal combustion engines

- The UK produces close to three million engines a year, or 25-30 % of total European output, and remains an important manufacturer on the international stage.
- Ford has approximately a quarter of its global engine production located in the UK and in 2006 announced a £1bn investment in low-carbon technology in the UK.
- The King Review for HM Treasury found that emissions from internal combustion engines could be reduced by up to 30 % over the next five to ten years. Some of the main areas of opportunity are in combustion and transmission technologies and engine downsizing.
- In addition to major manufacturers, the UK possesses a number of market-leading designers and developers of engines and engine-related technologies. An area of particular strength is diesel engine technology.
- However, the UK automotive engine industry faces a growing challenge from low-cost countries, which are beginning to play significant role in the manufacture of vehicles and engines.

Hybrid and electric vehicles

- The King Review suggested that the development of hybrid and electric vehicle technologies could result in cars emitting 50 % less carbon dioxide than today's equivalent models, becoming widely available by 2030.
- UK industry has significant expertise in a range of technologies key to hybrid 'powertrains' such as control systems and electric drivetrains.
- A major challenge for UK developers is to become the suppliers of choice of hybrid and electric powertrains for the major vehicle manufacturers.
- Diesel-hybrid technology could be a particularly significant area of opportunity. The hybrid market is dominated by petrol-hybrids, but diesel is emerging as the fuel of choice for passenger vehicles in Europe.
- The UK's combination of expertise in electric powertrain technology, a significant commercial vehicle industry and specialist suppliers of electric vehicles leave it well placed to exploit the emerging market for electric commercial vehicles.
- In the short-term, lack of consumer demand and a long-term carbon policy could constrain the market for hybrid vehicles.

"The challenge of developing state-of-the-art control systems and software is central to the effective implementation of the next generation of low emissions, fuel-efficient, combustion systems using both conventional as well as alternative fuels. Our work with Clean Air Power is an example of Ricardo's commitment in this area and demonstrates the value of applying the latest software and control systems technology in order both to enable and improve the operation of an advanced low CO2 combustion concept"

Stephen Montgomery, Director of Control Systems Software[24], Ricardo

Introduction

In this and the next section, we look at the opportunities for manufacturers to develop and make a range of low-carbon products. However, it is also important that manufacturers do not miss out on the associated service opportunities. This could involve providing spare parts and repairs or more sophisticated service offerings such as helping customers to make the most effective use of their products over their lifetime.

Recent EEF research shows that a growing number of manufacturers expect the provision of services to be amongst their top three sources of competitive advantage[25]. A recent report by Deloitte[26] also indicates that services can often be the most profitable part of a manufacturing business but that companies were missing out on these opportunities by failing to take a sufficiently strategic approach. This will be an important issue for manufacturers to address if they are to play a full role in the low-carbon economy.

24 September 2007, 'Ricardo assists Clean Air Power with low-CO2 technology' press release, Ricardo

25 (2007), *High Value – How UK manufacturing has changed*, EEF

26 Glueck, Koudal and Vaessen (2007), *The Service Revolution – Manufacturing's Missing Crown Jewel*, Deloitte

The road transport sector is the second-largest emitter of carbon dioxide in the UK. It accounted for over 20 % of total emissions in 2005 and is one of the few major sectors of the economy in which emissions are rising, having grown by 10 % between 1990 and 2005[27]. The sector will need to make substantial cuts in emissions if climate change policy objectives are to be met, making it a likely target for future regulation.

There is a range of vehicle technologies and fuels which could lower the carbon footprint of road transport. These include improvements to the internal combustion engine, alternative propulsion systems (e.g. hybrids, electric motors and fuel cells), increased use of light-weight materials (e.g. composites) and alternative fuels (e.g. biofuels and hydrogen). The technologies are at different stages of development but most of them are expected to play a role in reducing emissions at some point over the coming decades.

We have identified two major areas of opportunity for UK manufacturers in the near and medium term:

- Internal combustion engines; and
- Hybrid and electric vehicles.

Opportunities exist in other areas, such as biofuels and light-weight materials, but are not covered in this report. However, 'lightweighting' is worthy of mention and could prove a significant source of abatement and commercial opportunity. It has been estimated that a 10 % decrease in the weight of a car improves fuel economy by 7 %[28]. Major areas of R&D in lightweighting include carbon composites, aluminium and high-strength steels. The UK has a number of materials companies and vehicle manufacturers (e.g. Jaguar) active in this area.

Internal combustion engines

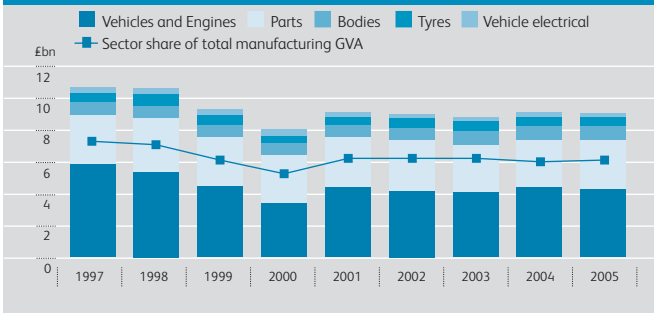
Potential market

As charts 6 and 7 show, automotive manufacturing remains an important part of UK industry and makes a significant contribution to the national economy, as illustrated by the following points:

- In 2005, the gross value added of the motor vehicles industry contributed £9bn to the UK economy and represented 6 % of total value added in the UK manufacturing sector.
- The production of vehicles and engines is a major contributor to the UK automotive industry, accounting for nearly 50 % of gross valued added in 2005[29].
- Engine production is one of the strongest elements of the UK's automotive manufacturing industry. The UK produces close to three million engines a year, or 25-30 % of total European output, and remains an important manufacturer on the international stage.
- Whilst the number of cars produced has declined slightly in recent years (by 8 % between 1999 and 2004), the production of automotive engines has increased significantly (by 29 % between 1999 and 2004).

Chart 6 Engine and vehicle production a major contributor to UK automotive industry

Gross value added (GVA) by component type and sector share of total manufacturing GVA



Source: BERR

Growth in the output of engines has been driven by the establishment of new facilities (e.g. BMW's engine plant in Warwickshire) and the expansion of existing ones (e.g. Ford, Honda and Toyota plants). Ford Motor Company has approximately a quarter of its global engine production located in the UK and in 2006 announced a £1bn investment in low-carbon technology over six years in the UK[30]. The investment has been allocated to a range of technologies, including the development of more efficient engines.

27 See www.defra.gov.uk/environment/statistics

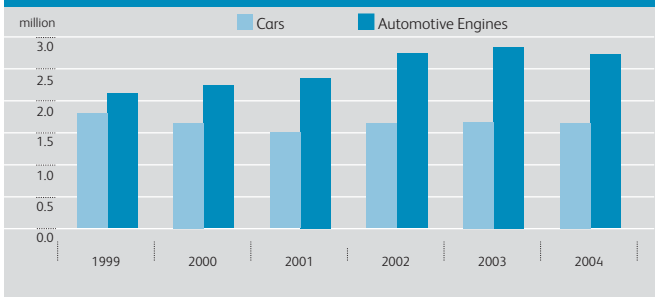
28 Pernick and Wilder (2007), *The Clean Tech Revolution: The Next Big Growth and Investment Opportunity*

29 See www.autoindustry.co.uk/statistics

30 Mark Milne (2006), *Ford Puts £1bn Behind UK Research in Drive to Cut Carbon Emissions*, The Guardian

Chart 7 Automotive engine production in the UK is buoyant

Production volume



Source: BERR

As part of Budget 2007, HM Treasury announced that a team led by Professor Julia King would review how best to achieve substantial reductions in road transport emissions over the next 25 years. The first part of the 'King Review' was issued in October 2007. One of the key findings was that emissions from internal combustion engines could be reduced by up to 30% over the next five to ten years.

This would be done through the widespread application of existing or near-to-market technologies to new models[31]. A study by E4Tech, published in March 2007, estimated that improvements to the internal combustion engine could yield emission reductions of 15-20% by 2020[32].

The internal combustion engine is a well-established part of the UK automotive industry and has almost total worldwide market penetration. Car manufacturers expect it to remain the core propulsion technology and a major part of their business for the next 20 to 30 years[33]. However, the trend towards greater regulation of carbon dioxide emissions means that the onus will be increasingly on the automotive industry to reduce the carbon footprint of its engines.

Opportunities for UK industry

A range of existing and near-to-market technologies offer the prospect of significant improvements in the efficiency of the internal combustion engine and the associated 'powertrain'[34].

Some of the main areas of opportunity are:

- **Combustion technology:** improving the efficiency of the combustion process such as 'direct injection' (increasing efficiency of fuel burn), 'variable valve actuation' (optimisation of the flow of fuel into the combustion chamber) and 'variable compression' (optimisation of the compression on an engine to match operating conditions).

- **Transmission technology:** improving the efficiency of transmission such as 'infinitely variable transmission' (IVT) and 'dual clutch transmission' (DCT).

- **Engine downsizing:** improving the power-to-weight ratio of an engine and enabling greater power output for a given size. These include 'boosting' technologies such as 'supercharging' and 'turbocharging' which work by increasing the pressure of the air in the fuel mixture fed into the engine.

The size, diversity and expertise of the UK engine industry suggests that business opportunities exist for UK manufacturers and developers in the pursuit of more efficient and less polluting internal combustion engines.

Development and manufacturing of high-efficiency internal combustion engines

In addition to major manufacturers, the UK possesses a number of market-leading designers and developers of engines and engine-related technologies. An area of particular strength is diesel engine technology. The combination of a strong manufacturing base, specialist technology suppliers and leading engine developers makes the UK automotive sector well-placed to capture a significant share of the market for high-efficiency internal combustion engines.

Japanese vehicles manufacturers are significant investors in the UK and traditionally seek to develop long-term partnership relationships with local suppliers. The greater degree of stability and involvement afforded by these more strategic relationships allows suppliers to invest with more confidence in new technologies[35]. They could therefore play a key role in facilitating the growth of smaller suppliers in the automotive engine sector.

In addition to a strong automotive engine industry, the UK is host to a number of leading developers and suppliers of diesel engines for heavy vehicles. These include manufacturers of engines for off-highway heavy vehicles (e.g. agricultural and construction machinery), such as Perkins and JCB, and manufacturers of engines for on-highway heavy vehicles (e.g. trucks, buses and coaches), such as Cummins. Each of these companies maintains significant

31 Professor King (2007), *The King Review of Low-carbon Cars – Part I*, HM Treasury

32 E4Tech(2007), *A Review of the UK Innovation System for Low Carbon Road Transport Technologies*, Department for Transport

33 (2006), *Postnote: Low Carbon Private Vehicles*, Parliamentary Office for Science and Technology

34 The 'powertrain' refers to the group of components in a motor vehicle that generate power and transfer and convert it into motion – i.e. the engine, transmission, driveshafts, differentials, and the final drive (i.e. drive wheels in the case of car)

35 Steve Parker and Bryan McGinity (2006), *Vision for the UK Automotive Industry in 2020: Focusing on Supply Chain and Skills & Technology*, Ricardo and Skills4Auto

R&D operations in the UK and is responding to the low-carbon agenda by exploring the scope for increased use of biofuels in their engines.

The challenge is to maintain the current levels of commitment from overseas vehicle manufacturers, increase inward investment where possible and for specialist UK suppliers and technology developers to continue to position themselves at the forefront of their markets through product innovation. The government must therefore ensure that the business environment remains attractive to existing and potential overseas investors in this industry.

Barriers for UK industry

However, the UK automotive engine industry faces a growing challenge from low-cost countries. There is also a danger that its reliance on foreign ownership could undermine its efforts to meet this challenge and gain a significant share of the business opportunities associated with improvements to the internal combustion engine.

Lower-cost countries are beginning to play a significant role in the manufacture of vehicles and engines. The increasing investment by Western European manufacturers in production facilities in Eastern Europe and the rise of China and India as major car producers are examples of this trend. These countries are becoming increasingly attractive locations, combining lower costs with rapidly improving skill bases. However, it should be noted that shifts in production have tended to be intra-regional, with new facilities remaining within the region in question, suggesting that cost has not been the only factor behind investment decisions.

Particularly vulnerable to direct competition from low-cost countries are component suppliers. Logistics can provide designers and system integrators with sufficient incentive to remain located near local car assembly plants. However, individual components may be easily outsourced to more cost-competitive economies[36]. It is therefore vital that UK manufacturers invest in new technology and in research, development and design.

Recent EEF research[37] shows that a growing number of manufacturers are competing by concentrating on higher value added activities. However, it also shows that transnational companies tend to concentrate many of these activities in their home country. Given the recent expansion in output and commitment to R&D in the UK by several major manufacturers, this is not necessarily a barrier to growth and investment in the UK engine industry. Indeed, engine manufactures have made significant long-term investments in the UK and the local supply chain, decisions which are not reversed without much consideration. However, it does underline the importance of making the investment in science, engineering and our skills base to make the UK an attractive place to undertake research and development.

Hybrid and electric vehicles

Potential market

Ultimately, there are limits to the emissions reductions which can be achieved through improvements to diesel and petrol engines. Alternative propulsion systems offer the potential to reduce significantly the carbon footprint of cars in the medium-to long-term. The King Review suggested that the development of hybrid and electric vehicle technologies could result in cars emitting 50% less carbon dioxide than today's equivalent models (becoming widely available by 2030)[38]. The greater the use of electricity in road transport, the more its carbon footprint becomes linked to the nature of the power stations which supply the electricity. A generation portfolio dominated by renewables and nuclear power, coupled with electric road transport, would deliver significant emission reductions in both sectors.

Hybrid electric vehicles (HEVs) combine petrol or diesel engines with powertrains that provide varying degrees of electric assistance to the main engine. There is a variety of hybrid types:

- **Mini hybrids** use 'stop-start' technology to cut the engine when a vehicle is stationary and restart it using energy stored in the battery.
- **Mild hybrids** also include 'regenerative braking' (i.e. the capture, storage and reuse of the energy which would otherwise be lost during braking) and 'electrical motor assistance' (i.e. inclusion of an electric motor in the powertrain to enhance performance of the engine) technologies.
- **Full hybrids** include all these features and are capable of running on the electric motor alone for limited distances.
- **Plug-in hybrids** have a battery that can be charged from the grid as well as from the petrol or diesel engine[39].

Several major manufacturers have been producing full hybrids for a number of years (e.g. Toyota has been producing its Prius since 1997). However, whilst the market

36 Steve Parker and Bryan McGinity (2006), *Vision for the UK Automotive Industry in 2020: Focusing on Supply Chain and Skills & Technology*, Ricardo and Skills4Auto

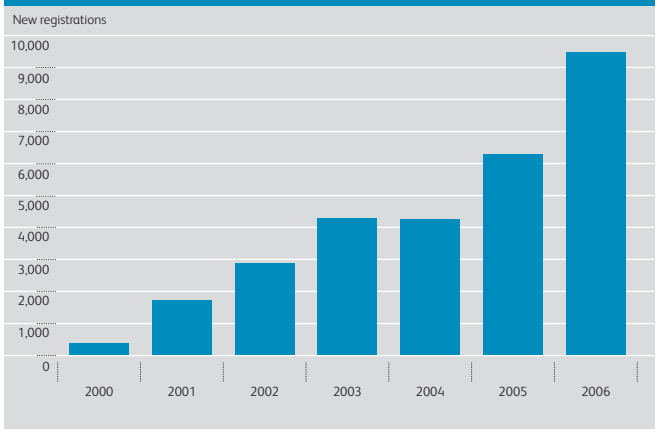
37 (2007), *High value – How manufacturing has changed*, EEF

38 Professor King (2007), *The King Review of Low-carbon Cars – Part I*, HM Treasury

39 E4Tech(2007), *A Review of the UK Innovation System for Low Carbon Road Transport Technologies*, Department for Transport

penetration of HEV and EVs is increasing, their share of the total market remains very limited. For example, in the UK, sales of alternative vehicles increased more than twenty-fold between 2000 and 2006, but still represented less than 0.5 % of new registrations in 2006.

Chart 8 UK sales of alternative-fuelled vehicles modest but rising



Source: SMMT

However, petrol-hybrids dominate UK sales of alternatively-fuelled vehicles, accounting for approximately 95 % in 2006. In addition, elements of hybrid technology are increasingly being incorporated into the mainstream models of a number of major car manufacturers (e.g. stop-start technology in the Citroen C3).

Electric vehicles (EVs) dispense completely with the internal combustion engine and run on electric power alone. EVs have dominated a number of niche, off-highway, vehicle markets (e.g. forklift trucks) for many years. However, their penetration of the mainstream road transport market is minimal. Battery technology currently limits the range and performance, and hence application, of EVs.

Opportunities for UK industry

The most significant opportunities for UK industry in the HEV sector are to develop and manufacture:

- hybrid powertrains; and
- niche electric vehicles.

Development and manufacture of hybrid powertrains

Alongside battery technology, the integration of mechanical and electrical components into a single 'hybrid' powertrain is one of the key areas in development of HEVs. UK industry has significant expertise in a range of technologies key to hybrid powertrains, such as control systems and electric drivetrains.

The UK has a number of market-leading developers of hybrid technology:

- Lotus Engineering is collaborating with its parent company on an innovative hybrid system capable of being retrofitted to cars not originally designed to be hybrid[40].
- Ricardo is collaborating with AFS Trinity on the design and development of the powertrain for a plug-in hybrid.
- Zytek designs and produces the motor for the fully-electric version of the 'Smart' car.
- UK-based vehicle manufacturers are also actively pursuing innovations in the area. For example Land Rover is developing a four-wheel drive hybrid system capable of being applied across its product range[41].

Zytek Group Ltd

Zytek is a British engineering company at the forefront of technological developments in the automotive sector. The company employs 180 people, and has an annual turnover of £25m, 10 % of which is re-invested in R&D.

The company supplies a range of products and services integral to lowering the carbon footprint of road transport. These include electric engines, engine management systems, electrically-operated gearshift systems (EGS) and the integration of electric and hybrid powertrain systems for concept and production vehicles.

Zytek provides solutions to the world's leading automotive groups as well as pioneers of the new wave of electric vehicles. This includes developing advanced powertrain control systems for Continental and supplying electric engines for DaimlerChrysler's Smart EV and Modec's delivery vehicles.

Zytek is also working successfully with the public sector to move forward the low-carbon agenda in road transport. In response to the Energy Saving Trust's 'Ultra Low Carbon Car Challenge', Zytek has successfully developed a hybrid family car capable of mass production. In June 2006, the company was awarded UK government funding to develop a 7.5t hybrid commercial vehicle demonstrator. The 20-month development programme is scheduled for completion in 2008.

40 See www.cleangreencars.co.uk

41 See www.autocar.co.uk

Modec's electric urban delivery van is powered by a Zytek electric drivetrain

Smart electric vehicles in Zytek's Fradley workshop

The UK automotive industry has the opportunity to establish itself as one of the leading centres for the design, development and manufacturing of hybrid and electric powertrains. The challenge for UK developers is to become the suppliers of choice for the major vehicle manufacturers.

Diesel-hybrid technology for passenger cars could be a particularly significant area of opportunity. The hybrid market is currently dominated by petrol-hybrid technology. This reflects the fact that hybrids were commercially pioneered in Japan with a view to the home market and the world's largest car market – the USA. Both markets are dominated by petrol-fuelled vehicles and have low penetration of diesel cars. In Europe, however, diesel-fuelled cars account for about half of all new sales.

UK companies have the opportunity to leverage their expertise in diesel and powertrains technology to exploit this gap, in collaboration with major European vehicle manufacturers. Some are already doing so. In response to the UK Department for Transport's 'Ultra Low Carbon Car Challenge', Ricardo led a consortium, comprising QinetiQ and PSA Peugeot Citroen, which successfully developed a diesel-hybrid prototype car in 2006. Further research is being carried out to refine the technology.

Companies such as Leeds-based bus manufacturer Optare have already proven that a market exists for diesel hybrids in the heavy vehicle sector. Optare manufactures a range of diesel-hybrid buses. The hybrid power pack for Optare's Solo bus model is designed and manufactured by Sussex-based Traction Technology plc. The two companies are collaborating on the use of super capacitor technology as an alternative to batteries for the storage of electricity within hybrid vehicles.

Optare Group

Optare is a leading UK-based bus manufacturer. The company has 550 employees and an annual turnover of £60m.

From its manufacturing facilities in Leeds and Rotherham, Optare supplies a range of buses to the domestic market and a number of other major markets worldwide such as the USA, Germany, Malaysia and Turkey. As well as supplying vehicles directly, Optare collaborates with local partners through technology transfers and licensing agreements.

The company's product range is complemented by a complete service offering which covers: product design, training, servicing, provision of parts and financing. Three service centres (in Rotherham, Thurrock and Cumbernauld) and mobile service technicians provide nationwide coverage.

Optare was a pioneer in the manufacture and introduction of low-floor/easy-access vehicles in the UK as well as supplying increasingly fuel-efficient and environmentally-friendly buses. In addition, several of its models, including the Solo, are now available as diesel-electric hybrids.

Development and manufacturing of niche electric vehicles

EVs have dominated a number of niche, off-highway, vehicle markets (e.g. forklift trucks) for many years. However, their penetration of the mainstream road transport market is minimal. Higher upfront costs, limited range, slow re-charging times and little or no charging infrastructure have inhibited their uptake by consumers. However, things are beginning to change. Commercial fleets are emerging as a promising lead-market for EVs. And the UK automotive sector is well positioned to take advantage of the opportunity (and in some notable cases is already doing so).

EVs are beginning to penetrate urban delivery vehicle fleets as they do not face the same constraints as passenger cars. Delivery vehicles operate within limited areas and can be recharged at the depot. As a result, ranges can be more modest than they would need to be for passenger cars and there is less of a need for dispersed recharging infrastructure. In addition, electric vehicles have an advantage over conventional vehicles in the stop-start conditions of urban delivery. Exemptions from road tax and the London congestion charge provide further financial benefits in the UK.

The combination of the UK automotive industry's expertise in electric powertrain technology and its significant

production of commercial vehicles make it ideally placed to take advantage of this emerging market. In excess of 200,000 commercial vehicles per year are currently produced in the UK and the country is home to major production facilities for leading brands such as Ford (e.g. Transit) and the LDV Group. The net result is the emergence of market-leading manufacturers of electric commercial vehicles. Two prominent examples are Modec and Smith Electric Vehicles.

Smith Electric Vehicles produces a range of electric delivery vehicles. High-profile customers include the Royal Mail, Sainsbury's, Scottish & Southern Energy and Marks & Spencer. Its smallest vehicle, the 3.5t Edison electric van, is built around the Ford Transit shell, demonstrating the potential for successful collaboration between the UK's emerging and established commercial vehicle manufacturers. In August 2007, Smith launched a left-hand drive version of the Edison for export to mainland Europe, where TNT of the Netherlands has already been secured as a customer. The company is also pursuing plans to develop larger vehicles for the North American market.

Coventry-based Modec produces a range of urban delivery vehicles powered by electric motors designed and developed by Zytek. The vehicles went into volume production in January 2007. A number of orders have already been taken from customers such as Tesco and Hildon Water.

In the short run, the UK automotive industry has the opportunity to build on its success to date in the development and manufacturing of electric commercial vehicles. In the longer run, the expertise and capabilities established in this niche market will be valuable and transferable to any wider deployment of EVs in the road transport sector.

Barriers for UK industry

A number of barriers exist which place a constraint on the market for hybrid and electric vehicles and hence the opportunities available for UK companies. The main barriers are:

- Major fixed investments in the internal combustion engine;
- Lack of consumer demand and choice; and
- Lack of a long-term carbon policy.

Major fixed investments in internal combustion engine technology

Vehicle manufacturers have invested considerable resources in the development and production of the latest generation of internal combustion engines. And they will be looking to secure a return on these investments as well as bringing new technologies to market.

Add to this the fact that manufacturers operate in a competitive global market, in which consumers place a premium on performance and reliability, and established technologies are likely to appear cheaper, more profitable and less risky to vehicle manufacturers in the short term.

As a result, some manufacturers may favour the gradual introduction of hybrid features in conventional cars over full hybrids until such time as the economics and level of demand for full hybrids become clearer.

Lack of consumer demand and consumer choice

Evidence suggests that environmental factors, such as the carbon footprint of a vehicle, are not major factors in purchasing decisions. Market research carried out for the Department for Transport in 2004 shows that only 3 % of respondents cited environmental factors as a major consideration when buying a car[42].

Consumers tend to take a relatively short-term view when weighing up the costs of a car, heavily discounting potential savings from a good fuel economy. Economic modelling undertaken by BP implies that car buyers look for an 18-month pay-back period for fuel costs[43].

The combination of the relatively high cost of hybrids[44], the limited importance attached to environmental factors by consumers and their short-term view of costs could place HEVs at a disadvantage in the marketplace and confine them to niche markets for the immediate future.

In the case of hybrids, the limited demand from consumers may in part be due to the restricted range of hybrid vehicles available on the market.

42 E4Tech(2007), *A Review of the UK Innovation System for Low Carbon Road Transport Technologies*, Department for Transport

43 Professor King (2007), *The King Review of Low-carbon Cars – Part I*, HM Treasury

44 Based on 2007 UK retail prices, hybrids typically add somewhere between £1,000 and £2,500 to the price of a vehicle. However, like-for-like comparison is not always possible because direct hybrid equivalents of conventionally fuelled models often do not exist

Lack of long-term carbon policy

Limited demand from consumers and the large sums manufacturers have invested in conventional engine technology suggest a key role for policy to drive the uptake of low-carbon cars.

UK government has put in place a number of successful schemes to support R&D in low-carbon vehicle technologies and has introduced fuel economy and carbon dioxide emissions labelling for new cars to satisfy EU legislation. However, neither domestic nor EU policy as yet provides a long-term incentive for manufacturers or consumers to make significant investments in low-carbon vehicles.

Currently, there is no clear policy framework providing a long-term view of the value placed on low-carbon road transport. Discussions are ongoing regarding the incorporation of road transport in EU ETS. In addition, the European Commission is due shortly to publish legislative proposals for a long-term framework for the reduction of carbon dioxide emissions from road transport shortly. There has been much discussion between the Commission and the automotive industry regarding the introduction of binding 2012 targets for the average emissions from new cars.

However, it is vital that the time horizon of any policy is compatible with product development cycles. A policy which sets a target for 2012 and is silent thereafter would not provide a sufficiently long-term signal to invest in low-carbon technologies with any degree of security. In addition, a target which is just four years into the future could be argued to be inconsistent with the product development cycles of the industry. The cars which will enter the market in 2012 are already being designed and under development in 2008.

4. Energy efficiency

Key points

- Industry has made significant progress in reducing 'direct' emissions of carbon dioxide. However, there is considerable scope to cut 'indirect' emissions by increasing energy efficiency.
- Annual emissions from the residential sector have risen by 5 % since 1990 and there is considerable scope to use energy more efficiently in the home. Major commercial opportunities exist for companies involved with domestic heating systems.

Motor systems

- Motor systems account for nearly 60 % of energy consumption in business. There is considerable scope to increase energy efficiency.
- Variable Speed Drives (VSDs) can reduce the electricity consumption of motor systems by up to 60 % by matching the speed of the motor to the requirements of the application.
- Currently their penetration remains low but rising energy prices and awareness of the financial benefits of greater energy efficiency could stimulate renewed interest in their uptake.
- UK industry is well placed to take advantage of this opportunity with a number of companies either manufacturing VSDs or offering motor system design and integration services.
- However, to realise these opportunities, the industry needs to develop ways to communicate the financial benefits more effectively to the end user.

Domestic heating systems

- Domestic heating accounts for approximately four-fifths of residential energy consumption and a quarter of total energy consumption in the UK.
- The UK is the largest gas boiler market in Europe, accounting for almost a quarter of annual sales across the continent. The UK is also a major designer and manufacturer of boilers.
- In the near term, most opportunities will probably be in high-efficiency condensing boilers, which recover and recycle most of the wasted heat that is lost to the atmosphere from the flue of a conventional boiler.
- Building regulations now require all new installations to be high-efficiency condensing boilers. However, boilers tend to be replaced only every 15 to 20 years.
- Accelerating the replacement cycle would yield significant benefits in cutting emissions and generate major business opportunities for boiler manufacturers but this would require incentives for potential purchasers to address the large upfront costs involved.
- Micro Combined Heat and Power (CHP) is the application of cogeneration (i.e. the simultaneous generation of electricity and useful heat) on a small scale – e.g. in the home or at the premises of a small business.
- An ongoing Carbon Trust field trial suggests that micro CHP could be suitable for a wide range of domestic settings and reduce carbon dioxide emission by 15 % to 20 % on these sites.
- There is considerable potential for micro CHP in the UK. It can be installed as a direct replacement for a gas boiler. The UK has a relatively old housing stock, a large installed base of gas boilers and an extensive gas distribution network. In addition, the comparatively low levels of insulation mean that the UK housing stock requires relatively higher levels of heating compared to its NW European neighbours.
- The UK boiler industry is well placed to benefit from this potentially very large market should it take off. The manufacturing base currently focused on condensing boilers could be, and in some cases already is being, adapted to produce micro CHP units.
- However, micro CHP units will remain more expensive to buy than condensing boilers for the foreseeable future and incentives would be required to accelerate their uptake.

Introduction

"A lot of investors are missing the point that most of the carbon savings are to come from reducing energy consumption. That means areas such as increasing efficiency, and improved vehicle and electronic technologies, are interesting. That is arguably a bigger market than renewables."

Charlie Thomas, Manager, Jupiter Clean Energy and Ecology funds[45]

45 Guardian Newspaper 2007, 26 November 2007

"In 2007, most investors' dollars were going into clean energy; 2008 is going to be the year of energy efficiency."

Dr Steve Mahon, Chief Investment Officer, Ludgate Environmental Fund

The industrial and residential sectors are significant emitters of carbon dioxide. In 2005, industrial emissions accounted for 18 % and residential emissions 15 % of the UK total[46]. There is considerable scope to use energy more efficiently, and hence reduce emissions, in both sectors.

The industrial sector has cut its annual emissions by 13 % compared to 1990 levels[47]. Achieving further reductions in 'direct' emissions is possible, but very challenging, as many of the most effective abatement options have already been exploited. However, opportunities exist to cut 'indirect' emissions – i.e. the emissions the industrial sector is responsible for as a result of its electricity consumption.

Annual emissions from the residential sector have risen by 5 % since 1990[48]. The combustion of fossil fuels for heating is the largest source of emissions in the sector and there is considerable scope to use it more efficiently.

Across these two sectors, we have identified two major areas of opportunity for UK manufacturers:

- industrial motor systems; and
- domestic heating systems.

Major abatement opportunities exist in other areas, such as lighting and insulation. However, they are considered less significant in terms of commercial opportunities for UK manufacturers.

Industrial motor systems

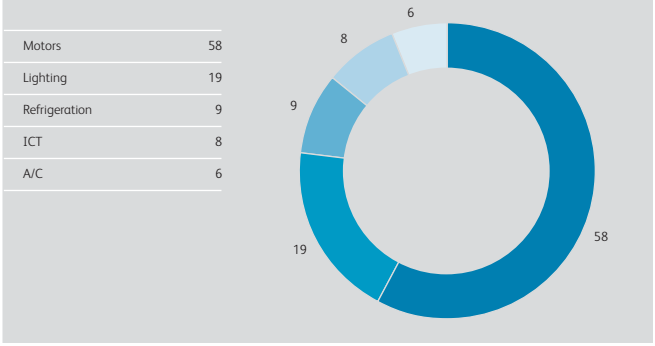
Potential market

Electric motors have a wide range of applications across the industrial and commercial sectors. Amongst other things, they power the pumps, fans, compressors and conveyors at the heart of industrial processes. It is estimated that over 11 million motors, with a total capacity of 90GW, are installed in UK industry[49].

Motor-driven systems consist of several components. Typically, a power supply, a control system, an electric motor, a mechanical transmission system and the machine being driven. Motor systems account for some two-thirds of electricity consumption on an average industrial site and approximately 40 % of national electricity consumption[50].

Chart 9 Motor systems are a major consumer of energy

% Energy consumption in the commercial and industrial sectors (2007)



Source: Market Transformation Programme

Considerable scope remains to increase the efficiency of motor systems and reduce the energy they consume. The core technologies comprising a motor system are well established. However, the market penetration of the most efficient models of some of the key components remains limited. For example, in 2005, 'Energy Efficiency Class 1' motors accounted for only 15 % of sales in the UK[51]. Their share of the installed base is even lower.

Many motor-driven devices (e.g. pumps and fans) are run inefficiently by (unnecessarily) operating them continuously at full speed. The inclusion of a Variable Speed Drive (VSD) in the system can ensure that the speed of the motor precisely matches the level at which the device needs to be operated at any given moment. Better matching of load to demand can save a considerable amount of energy.

Market conditions are changing. Two significant trends that should increase interest in more efficient motor systems are converging. Energy prices have risen steadily in recent years and consumers are becoming increasingly aware of the financial benefits of greater energy efficiency.

46 See www.defra.gov.uk/environment/statistics
47 See www.defra.gov.uk/environment/statistics
48 See www.defra.gov.uk/environment/statistics
49 (2006), *UK Energy Consumption of Industrial Electric Motor Systems*, Market Transformation Programme
50 (2006), *UK Energy Consumption of Industrial Electric Motor Systems*, Market Transformation Programme
51 (2006), *Sustainable Products 2006: Policy Analysis and Projections*, Market Transformation Programme

Opportunities for UK industry

Significant opportunities exist for UK developers, manufacturers and integrators of electric motor system components, in particular to:

- increase penetration of VSDs in traditional markets; and
- exploit new markets for VSDs.

Increase penetration of VSDs in traditional markets

The UK VSD market is worth approximately £100m a year. However, market penetration is low. The trade association representing suppliers of VSDs, Gambica, estimates that penetration could be as low as 10 % of all potential applications.

Siemens Standard Drives, Congleton

Siemens Standard Drives, based in Congleton, is a major manufacturing unit within Siemens's global Automation & Drives business. Established in 1992, the Congleton facility employs 420 people in the design, manufacture and support of a wide range of electronic variable speed drives (VSDs).

With an output in excess of 2,000 drives per day, the facility is one of the largest VSD factories in the world and one of the largest employers in the Congleton area. The business is expanding rapidly, with orders having grown by nearly 40 % over the last three years. Exports are driving that growth, with more than 90 % of output sold into markets outside the UK.

The electronic drives are used to control electric motors in a huge variety of industrial and commercial applications such as conveyor systems – for example, in excess of 20,000 units are used on baggage handling systems at Munich airport.

The plant has minimised production costs and maintained its competitiveness through a systematic implementation of lean manufacturing strategies together with flexible production techniques. In addition, it has won several prestigious manufacturing awards, including a UK 'Best Factory Award' for the Most Improved Plant in 2004 and more recently the EFQM prize for 'People Development and Involvement' in October 2007.

UK industry is well placed to take advantage of this market opportunity. The UK is host to a number of major VSD manufacturers – e.g. Siemens Standard Drives, Control Techniques, SSD Drives, Converteam and Invertek. Most have significant drive-related R&D operations in the UK in addition to their production facilities. The UK is a net exporter of VSDs, with the majority of output destined for overseas markets.

UK VSD manufacturers and a number of UK-based distributors of VSDs manufactured overseas (e.g. Schneider Electric, Moeller and ABB) complement their product offering with high value-added motor system design and integration services.

Nationwide, several thousand people are directly employed in the manufacturing, development, marketing and servicing of VSDs. In addition, the industry indirectly generates a number of other skilled jobs in the distribution of VSDs and their integration into industrial systems.

Increasing awareness of energy issues amongst consumers provides UK VSD manufacturers and motor system integrators with the opportunity to increase their sales. In addition to the benefits which would accrue to manufacturers and distributors from increased sales, greater use of VSDs could deliver significant long-term financial savings for UK industry through greater energy efficiency. A VSD can reduce the energy consumption of a motor system, depending on the application and context, by up to 60 %.

Exploit new markets for VSDs

VSDs offer potential energy savings in situations where an electric motor operates with a variable load – i.e. where the motor is not required to run continuously and is called into operation intermittently.

UK companies are actively exploring new markets for their motor control devices. For example, SSD Drives is currently researching the potential application of its VSD products in the renewable energy, automotive and off-highway vehicle markets. Wind turbines, hybrid-electric cars and forklift trucks all use electric motors intermittently.

Barriers for UK industry

A number of barriers exist to increasing the market penetration of VSDs:

- the typical route to market; and
- communicating the benefits to potential consumers.

SSD Drives Ltd

SSD Drives, based in West Sussex and part of the Parker Hannifin Corporation, is a leading manufacturer of industrial automation equipment. The company's portfolio of products includes a wide range of AC and DC drives, from 1 kW to 1 MW in power rating, suitable for a wide range of applications. Its product offering is complemented by support, training and drive system services.

Traditional markets for SSD's drive products include plastics, paper, metals, packaging and food processing. The company is also increasingly involved in emerging alternative energy markets, such as wind power, wave power, solar power and hybrid vehicles. Applications for its products in these markets include wind turbines and hybrid buses.

The multinational Parker Hannifin Corporation is a major manufacturer of automation products in the UK. Including the SSD Drives facility in Little Hampton, it operates 24 manufacturing facilities around the country.

Route to market

Typically, VSDs are not sold directly to the end user. The most common route to market is via a distributor or systems integrator – i.e. a third party. Such intermediaries can have quite different motivations from the manufacturer. For example, an integrator will source and combine the components for an industrial system (e.g. a cooling system) into a complete package for a consumer. This can act as a barrier to selling the financial payback benefits of using a VSD to the end user.

Any financial savings from using a VSD will accrue to the end user and not the integrator. The intermediary system integrator will often be motivated by a quite different incentive – putting together a competitively-priced package as part of a tender. As a result, integrators often overlook the long-run financial benefits (for the consumer) of using a VSD, in order to win a contract.

Communicating benefits

A more fundamental obstacle exists to communicating the benefits of using a VSD. The energy savings, and hence financial benefit, of a VSD depend on the context in which it is used (e.g. the industrial application), the nature of the system of which it is a part (e.g. the motor with which it is coupled) and how it is used (e.g. the frequency and intensity of use). Therefore, a VSD is not as easily amenable to a simplistic 'efficiency' rating as some other products.

Communicating the financial payback of using a VSD simply and concisely can therefore be challenging. A consequence of this has been that the industry and the Carbon Trust have had difficulties in reaching mutually acceptable criteria upon which to base the eligibility of VSD products for inclusion in its 'Energy Technology List' (ETL). The ETL provides Enhanced Capital Allowances (ECAs) for the consumption of selected energy-saving products and is a major route to market for their suppliers. However, both parties have been working hard to reach a mutually acceptable solution and significant progress has been made.

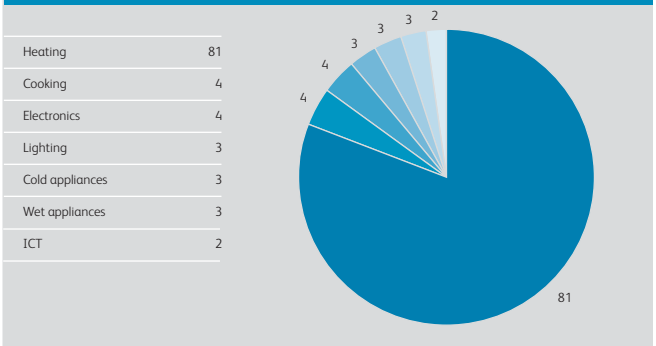
Domestic heating systems

Potential market

Keeping our homes warm, with all that entails, is a major source of energy consumption and carbon dioxide emissions. Domestic heating accounts for approximately four-fifths of residential energy consumption and one quarter of total energy consumption in the UK. The majority of central heating systems are fuelled by gas. Approximately 18 million homes have central heating systems, 90 % of which are gas-fired[52]. Domestic heating in the UK is therefore a significant source of emissions and boilers account for approximately 60 % of those emissions.

Chart 10 Heating accounts for 80 % of residential energy use

% Energy consumption in the residential sector (2007)



Source: Market Transformation Programme

The domestic heating and hot water market is dominated by 'wet' central heating systems – i.e. a boiler connected to a network of radiators. These types of systems account for nearly three quarters of the market. The remainder of it is contested by a variety of systems, including: warm air systems, community heating systems, underfloor heating, storage heating and solar thermal systems.[53]

52 See www.sbgi.org.uk

53 See www.energysavingtrust.org.uk

The UK is the largest gas boiler market in Europe, accounting for almost a quarter of annual sales across the continent – i.e. approximately 1.5m out of 6.5m units. The UK is also a major designer and manufacturer of boilers. A number of households names, some British- and some foreign-owned, have substantial production facilities in the UK. These include Baxi Group (includes Potterton, Baxi and Main brands), Worcester Bosch, Vaillant (includes Glow-worm brand) and Keston.

Worcester Bosch

Worcester, part of the Bosch Group, is the largest manufacturer of high-efficiency condensing boilers in the UK with an output of over 400,000 units a year. The company had a turnover of £275m and 1,800 employees in 2006.

Worcester manufactures over 100 models of Greenstar LPG, gas and oil-fired boilers all of which are A-rated on the SEDBUK scale, producing over 90 % efficiency. The complete series of Greenstar boilers has been built to cover virtually every domestic installation requirement for both interior and exterior applications. The Greenstar CDi gas boiler series has won the CORGI Boiler of the Year award for the last three years consecutively.

The company has also expanded its product portfolio to include renewable heating technologies: the Greenskies Solar water heating system and Greenstore Ground Source Heat Pumps, which provide an environmentally friendly solution to domestic heating and hot water.

Worcester has invested £3.4m in major R&D operations, employing 68 people in the UK. The company is actively considering designing, developing and producing micro CHP units in the UK.

Established and emerging technologies exist which can substantially reduce the carbon footprint of domestic heating. The combination of a viable range of technologies, the size of the domestic market and a substantial boiler industry all suggest opportunities for UK manufacturers.

Opportunities for UK industry

In the near term, most opportunities will probably be in high-efficiency condensing boilers. However, markets for a range of alternative heating systems, such as solar thermal systems and micro Combined Heat and Power (CHP), could take off in the medium term.

Accelerate retrofit of condensing boilers

Condensing boilers recover and recycle most of the wasted heat lost to the atmosphere from the flue of a conventional boiler. As a result, they are considerably more energy efficient. Modern conventional boilers operate at around 78 % efficiency, whilst condensing boilers convert more than 90 % of the energy contained in the gas they burn into useable heat[54].

Worcester Bosch – Green Star condensing boiler

Condensing boilers are starting to make inroads into the residential market. Policy support and regulation have played a key role in the growth of the market. The Carbon

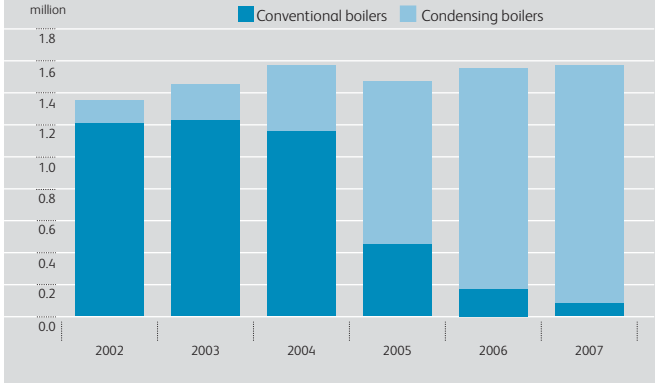
54 See www.energysavingtrust.org.uk

Siemens variable speed drive

Emission Reduction Target (CERT), introduced in 2002 and formerly known as the Energy Efficiency Commitment (EEC), provides incentives for utilities to improve the energy efficiency of the households they supply. In its initial stages, the incentives covered upgrades to condensing boilers. More significantly, building regulations which became effective in 2005 require all new installations to be high-efficiency condensing boilers. Between 2002 and 2007, condensing boiler sales rose from 11 % to 95 % of total gas boiler sales.

Chart 11 Regulation has catalysed market for condensing boilers

Annual boiler sales in the UK



Source: SBGI

Despite the rapid growth in sales, condensing boilers still only represent approximately 20 % of the total national stock of boilers. Based on current trends this will only change gradually. Boilers are typically replaced every 15 to 20 years. In the UK, this translates into a year-on-year turnover of approximately 5 %. Assuming this level of turnover, the Energy Saving Trust has estimated that 75 % of existing boilers will have been replaced by 2020[55]. Therefore, a substantial stock of less efficient, non-condensing boilers will remain over the next decade and beyond. The Society of British Gas Industries (SBGI) estimates that a substantial portion of that stock, about 4 million units, is especially old and inefficient – i.e. models with efficiencies in the region of 55-60 %.

Early replacement of these boilers would save a significant amount of emissions and represents an untapped business opportunity for UK condensing boiler manufacturers.

Establish micro CHP market

Micro CHP is the application of cogeneration (i.e. the simultaneous generation of electricity and useful heat) on a small scale e.g. in the home or at the premises of a small business. Cogeneration can offer significant energy savings

55 (2006), *The Rise of the Machines*, Energy Saving Trust

(and hence emission reductions) in situations where both electricity and heat are consumed.

Micro CHP systems are based around five main technologies:

- internal combustion engines;
- external combustion engines (i.e. 'Stirling' engines);
- steam engines;
- micro turbines; and
- fuel cells.

The engine-based systems are predominantly run on gas. Whilst CHP technologies are well established in industry, only a limited number of micro-CHP units are in use in homes and some of the more advanced technologies are still under development. For domestic applications, most currently available and near-to-market systems in Europe are based on Stirling engine technology. Japan, however, has demonstrated considerable interest in fuel cell technology and is currently conducting a field trial of such systems.

In November 2007, the interim findings of an extensive and ongoing field trial carried out by the Carbon Trust suggested that micro CHP could be suitable for a range of domestic settings and reduce carbon dioxide emission by 15 % to 20 % on these sites. These savings are likely to be achieved in larger, older less well-insulated residential building and small business premises. The project is one of the most in-depth field trials to date: 87 units, comprising 10 different models from 7 different manufacturers, are being tested in a range of domestic and commercial settings[56].

A number of factors suggest that there is considerable potential for micro CHP to expand in the UK and that manufacturers are well placed to take advantage of any growth in the market.

Micro CHP can be installed in new or existing homes and as a direct replacement for conventional gas-fired boilers. The UK has relatively old housing stock, a large installed base of gas boilers and an extensive gas distribution network. In addition, the comparatively low levels of insulation mean that the UK housing stock requires relatively higher levels of heating compared to its north-west European neighbours.

The substantial manufacturing base currently focused on condensing boilers could be, and in some cases already is being, adapted to produce micro CHP units. For example, Baxi Group, which already manufactures micro CHP units through overseas subsidiaries, is scheduled to launch a UK-produced micro CHP range in 2008. Worcester Bosch also has plans to design and manufacture micro CHP units in the UK in the near future.

Baxi Group UK

Baxi Group UK, part of the international Baxi Group, is one of the country's leading manufacturers of domestic heating systems. In 2006, it had a turnover of £360m and 2100 employees.

Baxi Group manufactures a range of high-efficiency heating systems including condensing boilers, hot water storage cylinders, fires, renewable energy and microgeneration products. Condensing boilers from its Baxi and Potterton brands have won several awards, including being rated 'Best Buys' by Which? in its 2007 review of boilers.

Baxi Group is investing heavily in new domestic heating technologies. The company is opening new state-of-the-art R&D and testing facilities in Preston in March 2008. Baxi Group's German subsidiary already manufactures CHP units and 2008 sees the launch of UK-manufactured micro-CHP systems.

The product has been developed specifically for domestic applications to provide a unit that operates virtually noise- and vibration-free, in a casing that is no bigger than a standard domestic boiler. The system has also been designed to operate using a range of low-carbon fuels: natural gas, LPG or biomass.

In addition, owing to the size of the boiler market and the particular characteristics of UK housing stock, the major manufacturers maintain significant R&D operations in the UK. As well as the major manufacturers, a number of technology developers are working on advanced CHP systems in the UK. For example, Ceres Power is developing fuel cells for micro CHP applications.

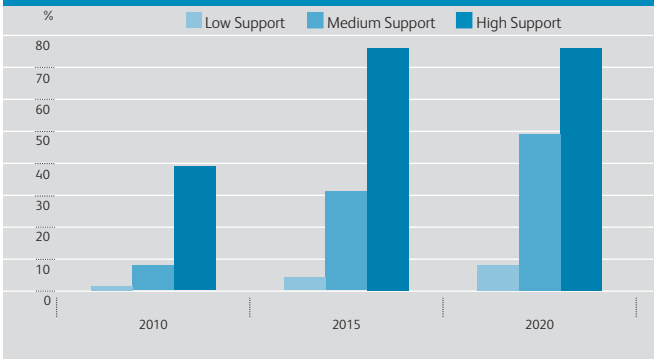
Given the early stage of the market, forecasts are limited and to a degree speculative. SBGI carried out an assessment of the potential UK market for micro CHP in 2006. The central finding was that, with appropriate policy support, micro CHP systems could capture approximately a third of the boiler replacement market by 2015[57].

56 (2007), *Micro-CHP Accelerator – Interim Report*, Carbon Trust

57 (2006), *MicroCHP – Updated Market Projections*, SBGI

Chart 12 Micro CHP could capture large share of the boiler replacement market

Micro CHP sales as % of boiler replacement market



Source: SBGI

Arguably, the study could be considered optimistic. The low-support scenario assumes no public subsidy and sees micro CHP remain a very limited niche market. The central scenario is based on the assumption that excess electricity will be credited at a premium rate (3p/kWh) and micro CHP installations will be subsidised by £200. The high-support scenario assumes the same premium for electricity support and an installation subsidy which brings the cost of a micro CHP unit down to the same level as that of a conventional boiler. What the study illustrates is the potential for micro CHP in the UK but also that that it will be largely dependent on policy support for take off.

At present, the only major source of public support for micro CHP is the Low Carbon Buildings Programme (LBCP), which provides grants for the installation of micro-generation technologies (including micro CHP) to householders, the public sector and the private sector.

Barriers for UK industry

A number of barriers exist to accelerate the retrofitting of condensing boilers and establish a market for micro CHP:

- the nature of boiler purchases;
- the lack of incentive to retrofit condensing boilers; and
- the cost of micro CHP.

Nature of boiler purchases

Boiler replacement decisions can be significantly affected by a range of factors which detract from long-term considerations such as lifecycle fuel economy. For example, there is a 'hassle' factor involved with replacing a central heating system in a home. The desire to minimise disruption can limit the extent to which householders explore all available options. Similarly, most boiler replacements are 'distressed' purchases – i.e. urgent replacements of failed systems during the winter. Again, such circumstances can result in quick installation taking precedence over a long-term view of energy efficiency.

Lack of incentive to retrofit condensing boilers

The main barrier to accelerating the rate at which conventional boilers are replaced by condensing boilers is the lack of sufficient financial incentive for the consumer. Under the 'Magic Boiler Scheme', which is backed by the Energy Saving Trust (EST) and ends in 2008, the industry offers modest cash-back incentives (£20 in 2006) on a range of condensing boilers. However, condensing boilers are not eligible for a grant under the LBCP. In addition the incentives provided by the old Energy Efficiency Commitment (EEC) are no longer available.

The lack of sufficient incentives is especially acute in the case of rented accommodation. In this situation, there is no clear incentive for either party to incur the cost of replacing a conventional boiler with a condensing boiler.

In contrast to the UK, some countries continue to offer substantial incentives. For example, in the United States, there is a $300 federal tax rebate for the installation of condensing boilers. A number of years ago the EST did offer a £200 cash-back incentive for the installation of condensing boilers, but the scheme has long since been discontinued.

Given the slow turnover rate in the market and the upfront cost of installing a new boiler, the government and boiler manufacturers should strengthen the financial incentive for householders to replace traditional boilers with more efficient condensing models.

Cost of Micro CHP

Domestic micro CHP units are more expensive than condensing boilers. For example, in 2005, WhisperGen's 1Kw micro CHP system was approximately £500 more expensive than a comparable boiler[58]. However, Cogen Europe, the European trade association for CHP, estimated that the additional upfront cost of Whispergen units would be recouped in less than three and a half years through lower electricity bills[59].

58 WhisperGen is a New Zealand based company and a market leader in domestic scale micro CHP. Its 1kw sterling engine units are of the most popular micro CHP products in the Europe.

59 (2005), *Micro-CHP Factsheet: United Kingdom*, Cogen Europe

Although micro CHP can deliver significant financial savings over the lifetime of its installation, it is likely remain more expensive to buy than condensing boilers for the foreseeable future. Therefore, reducing the cost differential should be a key target for both government and industry.

Some incentives for purchasing micro CHP systems already exist. In April 2005, VAT was reduced from 17.5 % to 5 % for micro CHP products. In addition, micro CHP is eligible for grant funding under the LBCP. However, the domestic heating industry considers that the programme is flawed in several key respects.

First, the maximum grant per household has been cut since the scheme started. Second, the requirement to have secured planning permission for the installation of a system before an application for funding can even be made is seen as a major disincentive for domestic applicants. Third, and perhaps most importantly, the accreditation/certification process for installers, for which there is a single awarding body, is seen as unnecessarily restrictive and costly. Both manufacturers and installers believe these issues act as a major constraint on the pace of deploying micro-generation technologies.

Government and industry should consider strengthening financial incentives for the appropriate uptake of micro CHP. However, there are potential conflicts involved in encouraging the growth of condensing boilers and domestic micro CHP. In particular, a policy that achieved a significant acceleration in the retrofitting of condensing boilers could effectively lock out micro CHP from the residential market, given the long lifetime of boilers. It is important for the government to recognise and resolve these conflicts in developing a strategy to make homes more energy efficient.

5. Recommendations

The transition to a low-carbon economy provides UK industry with a number of business opportunities across a range of established and emerging technologies. This report has focused on some of the major areas of opportunity in energy supply, road transport and energy-efficient products. Making sure that UK manufacturers are in a position to take advantage of these opportunities will require a long-term partnership between government and industry in three key areas:

- creating a conducive business environment;
- establishing a strategic policy for key technologies; and
- empowering consumers to make low-carbon choices.

Creating a conducive business environment

To help manufacturers realise the opportunities identified in this report, UK government and its agencies need to create and sustain a business environment which will encourage a low-carbon economy to emerge. This will take the form of policies to encourage the development of low-carbon markets, as well as measures to support UK industry in realising the opportunities that they present.

> *"Manufacturers are very smart; if you give them a solid framework and solid targets that will stand for a period of time so they have the incentive to invest, they will do the innovation and find alternative, lighter materials. We shouldn't force manufacturers to follow a particular route, but allow them (in the market) to deliver the outcome in the most efficient way."*
>
> **Phil Sivell**, Chairman of Inter-Regional Climate Change Group, Transport Research Laboratory[60]

Give greater priority to research and development

For UK manufacturers to realise the business opportunities presented by a low-carbon economy it is vital that they make a sustained commitment to investing in research and development (R&D). It is also important that the government backs business by providing the support that will ensure manufacturers undertake the R&D and develop the next generation of products in the UK. These include the fact that in a number of the industries analysed in this report a large role is played by foreign-owned firms who tend to do much of their R&D in the parent country. In addition there is a risk that the trend to locate more production in emerging economies will mean that R&D follows it out of the UK, given that there are often significant advantages in co-locating both activities.

The government's strategy on science and innovation, involving amongst other things a significant investment in science, R&D tax credits and efforts to improve links between universities and business, is starting to deliver results. However, it needs to build on this by ensuring that the Technology Strategy Board, which is tasked with promoting high-risk innovation in leading edge technologies, treats the development of low-carbon products as a priority and that this is backed by government R&D spending.

Energy is a particular case in point. Public funding for energy-related R&D in the UK is significantly lower than it is in any of the other major industrialised nations. The establishment of the Energy Technologies Institute is welcome, but the additional funding announced will still leave the UK behind its major competitors. Government must increase support for energy-related R&D and should use a share of any EU ETS auction revenues to fund the increase. In addition, financial support should be refocused on technologies which offer the greatest long-term abatement potential and/or the most promising economic opportunities for the UK industry.

Give greater priority to the next generation of scientists and engineers

Urgent action is needed to improve the supply of employees with high levels of skills in science, technology, engineering and mathematics (STEM) subjects.

Lord Sainsbury's review of the government's policies on science and innovation contained a number of welcome measures to improve the quality of teaching of STEM subjects and ensure that young people get good quality information about the associated career options. In response, government made a number of commitments. These included increasing the supply of well-qualified teachers in these subjects and investing in the continuing professional development of teachers and careers advisers to ensure that they are up to speed with leading-edge manufacturers. In addition a significant expansion in the number of science clubs has been promised. The government must deliver on these commitments by backing them with resources.

However, business also has an important role to play by developing stronger links with schools and inspiring teachers and students with what they are doing to deliver the low-carbon economy. Wider appreciation of the central role science and engineering skills play in addressing climate change, one of the most pressing issues of our time, could prove a powerful tool for encouraging more young people to study technical subjects and pursue technical careers.

60 Interview with Daily Telegraph February 2007

Follow through planning reforms

The government must also ensure that the planning system does not impede the development of the low-carbon economy. The key area that needs to be addressed is the way that planning systems have slowed delivery of many forms of renewable energy such as offshore wind. Reforms designed to facilitate the development of energy infrastructure are currently in the legislative process. If and when these reforms are adopted, government must demonstrate the political will to implement the reforms effectively.

Given the government's commitment that most new homes will be 'zero carbon' from 2016, it is also important that the planning system does not slow the construction of new homes. It must also take steps to ensure that businesses seeking to improve their energy efficiency (by making structural improvements to their existing buildings or moving to new ones) are not held back by the planning system.

Establishing a strategic policy for key technologies

Several emerging low-carbon technologies are particularly important because they offer both significant abatement potential and major opportunities for UK manufacturers. However, owing to the relative immaturity of the technologies, strategic policy support is needed if these opportunities are to be realised.

Provide targeted support for the wind energy supply chain

The offshore wind market seems poised for significant growth and next-generation turbines are under development. Whilst some UK companies are at the forefront of these developments, they have difficulty sourcing components locally. Government needs to provide targeted support to improve the capabilities of the UK supply chain. The Supply Chain Groups Programme should be replicated for the wind industry – the programme successfully assisted the automotive and aerospace industries to improve their global competitiveness.

Strengthening the UK supply chain would also make the UK a more attractive investment location for the major turbine manufacturers. Most of these companies are likely to be considering new production facilities in light of the tightening supply of turbines worldwide and the UK needs to improve its record in attracting investment from them. Rival locations are already making large investments to attract offshore turbine production facilities. For example, Bremerhaven in Germany has initiated a project to make the city a leading location for the manufacture of offshore wind turbines and has allocated significant resources to the project.

Develop a long-term strategy and review support for marine renewables

The UK is an early leader in marine renewables technology and has the long-term opportunity to develop a significant industry in this area. However, a number of the first commercial projects are scheduled to be completed for overseas customers using British technology and there is a danger that supply chains will be established in these countries. The government needs to set out a strategic vision for marine renewables and review the appropriateness of existing support mechanisms.

The existing mechanism used to encourage the development of renewable energy – the Renewables Obligation – is expensive and administratively complex and does not provide the predictability of long-term support required by private sector investors. In this respect it does not compare well with the support provided in countries such as Germany, Denmark and Spain where feed-in tariffs, guaranteeing a premium price over a long time period, have been instrumental in establishing their wind industries. The government therefore needs to look at the case for replacing the Renewables Obligation with a feed-in tariff for marine energy. It should also redeploy the support (available through the Marine Renewables Development Fund to support R&D) that would help developers to reduce the cost of their devices.

Establish a specific support mechanism for carbon capture and storage

Coal is the dominant fuel for electricity generation around the world and forecast to remain so over the next few decades. As a result, the potential market for carbon capture and storage (CCS) technology is huge. The UK has the manufacturing base, technological know-how and offshore infrastructure to establish itself as a lead market for CCS. However, long-term policy support is required to complete development and bring down the cost of the technology. The carbon price signal currently provided by the EU Emissions Trading Scheme (EU ETS) is insufficient as the price of carbon is highly volatile and the future of the scheme beyond 2012 is unclear.

Therefore, an additional and dedicated incentive is required for early projects which carry a 'first of a kind' risk and a disproportionately high infrastructure cost. This could take a number of forms, including: capital grants, tax credits, a feed-in tariff or guaranteed minimum carbon price. A share of the revenue raised from the auctioning of allowances in the

power sector under EU ETS should be used to fund the support.

Long-term, realistic European carbon dioxide targets for road transport

Significant, and potentially high-risk, investments are required to develop low-carbon vehicles. The product development cycle takes several years. Therefore, any policy to constrain carbon dioxide emissions from road transport must have set targets which respect the product development cycles of manufacturers. At the time of writing, the European Commission is considering the introduction mandatory carbon dioxide targets for new cars, based on the average carbon dioxide emitted per kilometre travelled. The UK government must use its influence to ensure that any such policy has a long enough time horizon to drive the investment required, and that the emission reduction targets set provide manufacturers with sufficient lead-time to develop new products in response.

Reform support for micro combined heat and power (CHP)

A number of micro-generation technologies exist. Micro CHP, which could be a direct replacement for gas boilers, is particularly promising for UK industry. The UK is the largest gas boiler market in Europe and has a number of major boiler manufacturers capable of developing and supplying micro CHP products. However, the comparatively high cost of micro CHP could act as major barriers to its uptake.

Government should explore options for encouraging the installation micro CHP. These could include financial incentives to purchase micro CHP systems (e.g. a cash back scheme) and guaranteed payment for excess electricity generated (e.g. feed-in tariffs).

The Low Carbon Buildings Programme, the only significant support mechanism for micro CHP currently in place, is in urgent need of reform. Specifically, government should reconsider the requirement (for those planning to install a micro CHP device) to seek planning permission prior to applying for funding. It also needs to start investing in the skilled staff required to ensure that an appropriate number of installers of micro-generation products can be certified at reasonable cost.

Empowering consumers

Consumers must be empowered to create the demand which will enable markets in low-carbon products to take off. Working in partnership, government and industry need to ensure that consumers have the ability to make informed purchasing decisions, that low-carbon products are financially accessible to as wide a range of them as possible and that they have a wide choice of low-carbon products.

Enable consumers to make informed decisions

To make informed purchasing decisions, consumers need to be provided with simple and reliable means through which to compare both the carbon footprint and the energy consumption of different products. Government and industry need to work together to develop easily-understood and widely-accepted measures of the carbon footprint of a product. A number of carbon-labelling initiatives are already being developed in both the public and private sectors. These efforts need to be coordinated to ensure that messages to consumers are consistent and to avoid undermining the credibility of carbon labelling.

In many cases the carbon footprint of a product will be driven by its energy efficiency. Manufacturers need to provide consumers with clear information about the energy consumption of their products and, most importantly, how this translates into potential financial savings for the customer. This is especially important where the energy-saving potential of a product is heavily influenced by the manner and context in which it is used (e.g. variable speed drives).

In addition to communicating the right message, manufacturers will need to ensure that they are communicating with the right party. The financial benefits resulting from using less energy typically accrue to the end user. Where the route to market is via an intermediary, communicating these benefits to the end user is more challenging. For example, selling variable speed drives via a system integrator limits a manufacturer's ability to promote its product on the basis of the payback it delivers through greater energy efficiency.

Make low-carbon products more financially accessible

Low-carbon products need to be made accessible to as wide a range of consumers as possible. Initially at least, low-carbon products will tend to be premium products – i.e. they will cost more than their conventional equivalents. Financial incentives for the uptake of those products which offer both significant abatement potential and major opportunities for UK industry should be strengthened. Meanwhile manufacturers will need to support low-carbon products with a range of financing options that will make them more affordable and broaden their appeal (e.g. hire purchase or offsetting installation costs against reduced energy bills). In addition, the possibility of alternatives to selling products (e.g. leasing) should be explored. However, options such as

leasing may be more appropriate for small business rather than domestic customers.

Incentives to accelerate the retrofitting of condensing boilers should be a major priority. Domestic heating is one of the major sources of energy consumption and carbon emissions in the UK. Condensing boilers are considerably more efficient than traditional boilers and the UK has a major condensing boiler industry.

Market penetration of condensing boilers in the UK is above average and rising. However, because boilers have a long lifespan and incentives for early replacement are limited, a large stock of inefficient boilers could remain for a considerable amount of time. Government should provide an attractive and tangible financial incentive, such as a meaningful cash-back scheme, in order to accelerate the retrofitting of condensing boilers in British homes.

Broaden the range of low-carbon products

Manufacturers need to provide as broad a range of low-carbon products as possible to tap into latent consumer demand. For example, if market penetration is to increase significantly, car manufacturers will need to broaden their offering of hybrids to cover a wider range vehicle types, sizes and styles.

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- The Construction Products Association
- Converteam
- Doosan Babcock Energy
- The Energy Saving Trust
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- Gambica
- Jaguar and Land Rover
- The Lighting Association
- The Low Carbon Vehicle Partnership
- Maesanturio
- Marine Current Turbines
- The Motorsports Industry Association
- Optare
- The Renewable Energy Association
- Rolls Royce
- The Society of British Gas Industries
- Sharp Electronics UK
- Shell
- The Society of Motor Manufacturers and Traders
- SSD Drives
- Toyota
- Wavegen
- WindSupply
- Worcester Bosch
- Zytek Group

About us

EEF is a trusted partner to thousands of employers around Britain. We work on behalf of over 6000 companies, in manufacturing, engineering, technology and beyond. Together, they employ close to a million people. On any given day you'll find us helping our members tackle a whole range of employment challenges.

Our regional Associations bring us much closer to the businesses we support, whilst our offices in London and Brussels stay equally close to government – influencing the way policy is made and alerting our members to any changes in legislation that might affect them.

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