Comparative advantage and green business

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Ernst & Young

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23 June 2008

Research project for the Department for Business, Enterprise and Regulatory Reform "Comparative Advantage and Green Business"

Dear Brian

In accordance with the engagement letter dated 5th February 2008, we enclose our report in relation to the analysis of "comparative advantage and green business". Our report focuses on the evidence on the potential business opportunities for the UK economy to move to a 'green' or low carbon, resource efficient economy.

Scope of our work

This scope sets out our understanding, based on discussions with you, of your objectives, the issues that are relevant to those objectives and the work we have agreed to perform. These Services are based on your Terms of Reference dated 5th February 2008.

In undertaking our work we have based our analysis and views on publicly available information, information provided to us by the Department for Business, Enterprise and Regulatory Reform (BERR) and our own information sources. The scope of our work has focused on four areas:

1. Definition and characteristics of green businesses – we define what is meant by and propose a framework of analysis for green business.

2. Assessing the UK comparative advantage – we identify sectors in which the UK has comparative advantage through analysis of trade data and analysis of foreign direct investment flows.

3. Characteristics of successful green business models – informed by a selected number of case studies of successful green businesses or clusters/regions, we draw out what are the key success factors for green business.

4. Policy impact and unintended consequences – through use of the Oxford Economic model, we illustrate the types of impact on the wider UK economy of different modes of developing green process and products in different sectors of the economy.

Purpose of our report and restrictions on its use

The Report has been prepared on the specific instructions of BERR. It is our understanding that BERR wishes to use the Report to inform the policy discussion about how to assist businesses moving to a low carbon and resource-efficiency economy. The Report should not be relied upon for any other purpose.

It is important to recognise that our work is limited to the scope described herein and has been carried out over a limited period of time, and is based on publicly available industry data, information supplied by BERR, and Ernst & Young proprietary information. It is possible that the Report, which does not constitute an audit, may not reveal all those matters which would have been identified by a full scope report. As a consequence, further and analysis will be required prior to relying on the information in the Report.

Yours faithfully

Ernst & Young LLP

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The Report was prepared solely for the use of the Department for Business, Enterprise and Regulatory Reform (BERR) and addressed issues specific to them. Accordingly, we may not have addressed issues of relevance to any other party. Further, the Report was concluded on 20th of June, and we have not undertaken any further work since that time. Material events may therefore have occurred which will not be reflected in the Report. The analysis has been based on information provided by BERR and on other publicly available sources.

Whilst we are prepared to provide access to the Report, it is only on the basis that it is acknowledged and agree that:

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We welcome feedback on the issues raised by this BERR commissioned study and comments should be sent to: berr.economics@berr.gsi.gov.uk

Executive summary

Climate change is recognised by most governments as a serious global threat that demands an urgent and collective global response. In response to such a threat, over the next 20 years there will be a shift towards a low-carbon, resource efficient economy and whilst this will inevitably be costly, there will also be considerable business opportunities and economic benefits to be gained.

The UK government has taken a lead in responding to the challenge of climate change and is driving the international debate on the issue, and has recently defined, through the Energy White Paper and the Climate Change Bill a clear framework to tackle such a challenge. It is crucial, however, that this is done in the most cost-effective way and that, in the process, economic growth, competitiveness, and job creation are stimulated. There is a need therefore to identify the sources of comparative advantage for one country and the potential business opportunities in a low-carbon or green economy. Comparative advantage in 'green business' (intended as low-carbon, resource efficient business) is therefore critically important to the UK sustainable development and is highly relevant to Government's commitment of ensuring business success in an increasingly competitive world.

In this context, the Department for Business, Enterprise and Regulatory Reform commissioned this study to gather evidence on the potential business opportunities for the UK economy to move to a 'green', or low carbon, resource efficient economy, and to inform the policy discussion about how to assist businesses to make that transition.

There are four key findings from this study:

1. A green economy will be one in which lower carbon and resource efficiency will permeate all products and services throughout the entire economy, and *we propose a wider definition and measure of green business to include all sectors of the economy*;

2. More *focus should be given to identify specific opportunities in the key sectors where the UK currently has comparative advantage*, in order to stimulate green products and services;

3. The *key success factors in a 'green business model' are entrepreneurship and innovation* which seem to enable the development of green businesses that are likely to be more sustainable than through direct policy support, seeking to bestow comparative advantage in green business where no such advantage naturally lies;

4. The *impact at a sectoral level is likely to be highly varied*, not just in outcome but also in different types of transmission (from action to outcome). Spillover effects in some types can be significant, and therefore, under these conditions, our simulations indicate that while some developments could boost UK GDP others could have a negative impact on GDP – particularly for some sectors.

Taking each of the four points in turn we summarise how we came to our conclusions:

1. *We propose a wider definition and measure of green business to include all sectors of the economy*

The traditional definition of Environmental Goods and Services (EGS) is not sufficiently broad to assess the opportunity for comparative advantage in green business. Green business itself is a very loosely defined term, which in our definition in Paper 1 allows expansion of green business to include businesses in, potentially, all sectors of the economy. We continue to recognise that some sectors will be able to transition to a green economy more readily than others, and so define a third set of sectors or businesses which are expected to be reactive rather then proactive in their adoption of solutions to shift to a low carbon economy.

We believe this definition enables businesses to consider how they create value – and contribute to comparative advantage – through addressing the climate change agenda directly or by having a greener business than their competitors in historically non-green sectors. We have proposed a supply-chain benchmarking tool which could be developed further by government or industry to help organisations assess how green their businesses are compared to their peers in the UK and internationally.

2. *Focus should be given to the sectors where the UK currently has comparative advantage*

Businesses can gain comparative advantage in green business through two possible routes (depicted in Figure 1 of the main report). Route A stimulates comparative advantage in sectors and activities currently considered green or where there is an expectation of a significant green opportunity, but where the UK has little comparative advantage. Route B stimulates green products and services in areas where the UK already has comparative advantage.

In assessing Route B, we identify in Paper 2 eight sectors where there is evidence, based on trade and investment data, that the UK has comparative advantage. These sectors are then combined with the green business definition presented in paper 1, to identify the key sectors where the UK currently exhibits comparative advantage and could develop green business opportunities in specific sub-sectors; software, electronic equipment, business services, financial services, and machinery equipment.

In addition to the five sectors identified above, other sub-sectors have the potential to demonstrate comparative advantage. However, further work is required to define clearly these sub-sectors and their current and potential comparative advantage. We recommend further, more detailed, sub-sector analysis to identify specific areas of long term comparative advantage and consider ways in which to enable their more rapid transition to becoming low carbon, resource efficient green businesses.

Evidence suggests that policy drivers, whilst potentially widening the range of economic activities and opportunities in specific sectors, do not, on their own, and in the long run, yield sustainable improvement in comparative advantage, particularly when the full impact on the whole economy is considered. Therefore, more focus should be given to understanding the drivers of comparative advantage at a sub-sectoral level, and enabling businesses to develop green products and services in those sectors at which they excel.

3. *The key success factors are entrepreneurship and innovation*

Our case studies focused on a number of businesses and economies and how they have successfully developed comparative advantage in green business. The analysis presented in Paper 3 suggests that the drivers that spur a company or sector to become green (i.e., develop low carbon or resource efficient products) comes from demand side factors, either through policy measures (particularly regulation) or through a change in consumer behaviour; more specifically, in many cases, the anticipation of a change in regulation or consumer behaviour is the key driver for the most successful businesses. However, the key necessary *success factors* that enable businesses to successfully respond to such drivers seem to lie on the supply side, in creating the right conditions for the investment in and development of low carbon, resource efficient products.

We recognise that the key supply side success factors, such as access to capital, high level of investment in R&D, and a skilled labour force, are factors that support successful business in all high tech sectors, not only green or clean tech sectors. This suggests that policy makers should consider how to best align the demand factors, which can be influenced through regulation, and supply side factors, which can be influenced through business support policies, in order to encourage businesses to adopt such factors in implementing their green business strategies.

There is also evidence to suggest that while demand and supply side factors act together and reinforce each other to create specific successful green businesses such as in the Danish wind sector, in future the twin effects of global competition and adoption of green products and services beyond first mover markets, may make the support of supply side factors dominant over the demand side. The recent emergence and dominance of the US clean technology sector is taken as evidence of this future trend. The position of the UK as the most attractive location for venture capital investment in clean technology in Europe also tends to support the argument that a flexible and conducive environment to investment is a key to develop and support new technologies. Further and more detailed analysis of the trends and patterns for the particular sub-sectors of the clean technology market (particularly a comparative analysis of the UK versus the other largest European countries) might be appropriate to provide a clearer picture of the factors that will become critical over time in supporting investments in a low carbon economy.

4. *The impact at a sectoral level is likely to be highly varied*

In order to identify how the development of comparative advantage in green business might impact the UK economy, Oxford Economics have undertaken analysis using their proprietary general equilibrium Oxford Energy Industry Model which is presented in Paper 4. Four simulations of how developing green business in sectors where the UK currently has comparative advantage would impact on the wider UK economy have been developed. The fours simulations are:

1. On the supply side, a technology innovation yields both a greener and larger economy. A simulation is made of this occurring in the manufacturing sector;

2. On the supply side, a policy results in a greener but smaller economy. A simulation is made of this occurring in the renewable energy sector;

3. On the demand side, consumer preference creates the opportunity for a UK industry to develop a non-price comparative advantage related to greener production. A simulation is made of this occurring in the chemical sector; and

4. On the demand side, policy creates a new market in an area where the UK already has a comparative advantage. A simulation is made of this occurring in the carbon trading markets.

We have used conservative input assumptions in order to assess the impact on the wider UK economy in a highly controlled and constrained methodology. Even under these conditions, our simulations indicate that while some developments could boost UK GDP others could have a negative impact on GDP. Furthermore, the impacts within different sectors can vary significantly, and spillovers from one sector to another can be appreciable, particularly for enabling technologies. Further work might be required at a sectoral level to understand the strength of the various success factors and the relative relevance of policies for particular sectors.

In reality, input assumptions may turn out to be much stronger, and the transmission mechanisms likely to be less constrained, occurring in series or sequence. We recommend that the preliminary analysis undertaken here be extended using all four identified transmission modes in combination across many or all sectors of the economy, to assess if the aggregate impact on economic growth may be expected to materialise. We also note that traditional economic analysis of the type we have undertaken might not reflect the nature of a significant discontinuity such as climate change. Complimentary approaches may wish to be considered, such as analysis of how the UK created comparative advantage from other discontinuities such as the development and expansion of the internet.

Introduction

In his review of the economics of climate change, Sir Nicholas Stern concluded that the scientific evidence about climate change and the effect of global warming was now overwhelming. Climate change is a serious global threat that demands an urgent, collective global response. He was clear that the benefits of effective, early action on climate change far outweigh the costs and also estimated that the low-carbon energy product market could be worth over $500 billion per year by 2050[1]. Over the next 20 years there will be a shift towards a low-carbon, resource efficient economy and whilst this will inevitably be costly, there will also be considerable business opportunities and economic benefits to be gained.

The terms of reference for this study are to gather evidence on the opportunities for the UK economy to move to a 'green', or low carbon, resource efficient economy, and to inform the policy discussion about how to assist businesses to make that transition. We present our work in a series of four papers which analyse the key aspects of the issue as follows:

1. **Paper 1: 'Definition and characteristics of green businesses'**. In order to guide government policy and clearly understand what is being measured and incentivised, we first define what is meant by green business. A traditional, narrow definition of 'green' business has given way in recent years to a much wider range of businesses claiming 'green' to be part of their offering, and this paper explores this recent change and proposes a framework of analysis for green business which captures that recent change.

2. **Paper 2: 'Assessing the UK comparative advantage'**. We identify sectors in which the UK has comparative advantage through analysis of trade data and analysis of foreign direct investment flows. We also undertake an analysis of sub-sectors where the UK has comparative advantage and identify potential opportunities to build on that existing comparative advantage to develop green businesses. We find that developing comparative advantage in a green business where none currently exists seems more difficult than to exploit green opportunities where comparative advantage already exists.

3. **Paper 3: 'Characteristics of successful green business models'.** Informed by a selected number of case studies of successful green businesses or clusters/regions, we draw out what are the key success factors for green business. We identify the factors which drive companies to adopt green opportunities and provide an overview of the types of policies which have been introduced elsewhere to help such movement.

4. **Paper 4: 'Policy impact and unintended consequences'**. Finally, we determine the sectors which offer the best opportunities to develop a green business. Through use of the Oxford Economic model, we illustrate the types of impact on the wider UK economy of different modes of developing green process and products in different sectors of the economy.

Our work has been informed by a series of workshops both with BERR and other government stakeholders such as DEFRA, as well as an industry workshop involving companies from a wide range of sectors.

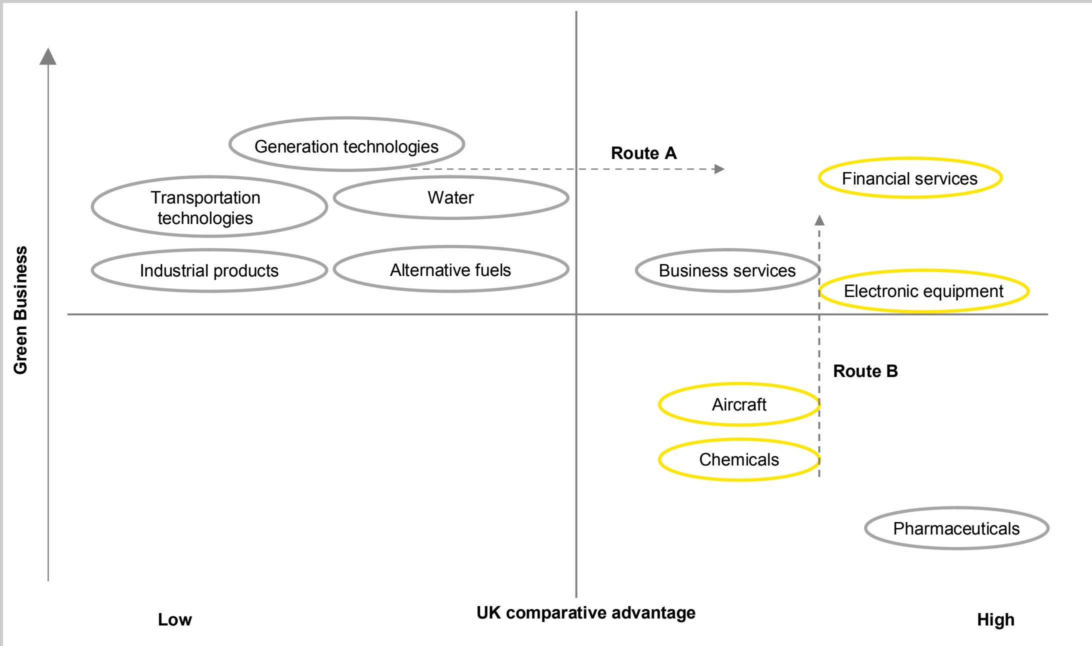
In achieving UK comparative advantage in green business, there are two routes to success, as shown schematically in the following diagram. Route A stimulates comparative advantage in sectors and activities currently considered green or where there is an expectation of a significant green opportunity, but where the UK has little comparative advantage. Route B stimulates green products and services in areas where the UK already has comparative advantage. Our study undertakes analysis of both routes. We estimate where the UK already has comparative advantage and identify opportunities to develop

1 See Stern Report at: http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm

green business in those sectors. We also assess how to create comparative advantage from green businesses where the UK does not currently have comparative advantage could be made to have so.

Figure 1: Comparative advantage and green business – routes to success

Source: EY analysis



The chart illustrates the two different routes towards developing successful comparative advantage in green business: either through gaining comparative advantage in existing green business (those sectors high on the y axis) or by developing green products in those business that already enjoy comparative advantage (those sectors to the right in the x axis). [2]

We avoid attempting to pick winners in this analysis, as by its very nature, innovation is unpredictable on where and how specific products and services are developed. Instead, we highlight the sectors where the UK currently has comparative advantage and where it seems to us that efforts to spur green business would best be directed. We see potential economic benefit in applying the principles of green business to sectors where the UK currently has comparative advantage. We have undertaken analysis to identify such sectors and describe the net economic impacts of the development of potential green processes or products that these sectors might deliver.

Our analysis is necessarily high level, as it focuses on the sector level which can therefore miss pockets of comparative advantage in specific sub-sectors. We acknowledge that the opportunities for developing comparative advantage in green business are not exhaustively listed here, and real opportunities may lie in areas not identified in this analysis. However, for the purposes of informing government policy and guiding investment decisions, we believe the approach adopted here is robust at the macro-economic level.

We also note that this analysis is not directed at addressing how the UK economy can reach its carbon or environmental targets, but rather the potential opportunities that lie for UK businesses from shifting to a low carbon and resource efficient economy.

[2] The x axis illustrates the degree of comparative advantage for each sector – metric used to approximate this is the specialisation index (or measure for Revealed Comparative Advantage) explained later in paper 2. The y axis illustrates the degree of 'greenness' of the different sectors – metrics used is explained in paper 1, and include the energy intensity and carbon intensity of a sector as an example.

Contents

1. Paper 1: Definition and characteristics of green businesses

1.1 Executive summary

As the debate around how to address the climate change challenge intensifies, a large number of companies in all sectors – from supermarkets to car manufacturers – are beginning to adopt green products and solutions. Many if not most companies are keen to re-define themselves as 'green business'. The traditional definition of 'green business' as Environmental Goods and Services (EGS) therefore no longer fully captures the range of companies and sectors active in what we can call 'green activities'. This paper proposes a wider definition of the characteristics of green businesses in order to capture more comprehensively the dynamics and drivers of green business. We recognise that some sectors will be able to transition to a 'green' economy more readily than others, and so in our definition we separate those sectors or businesses which are expected to be reactive from those that are being proactive in implementing green practices.

We believe this definition enables businesses to consider how they create value – and gain comparative advantage – through addressing the climate change agenda directly and so developing a 'greener business' than their competitors in historically non-green sectors. We have proposed a supply-chain benchmarking tool which could be developed further by government or industry to help organisations assess how green their businesses are compared to their peers in the UK and internationally. We apply our methodology to a worked example to show how a company active in a non-traditional green sector can be influenced by demand and supply side factors to become greener compared to a benchmark level.

The second part of the paper then looks at the specific areas where green business investment opportunities lie. We take as a proxy for green business opportunities, the breakdown of venture capitalist investment in the clean technology sector. The UK emerges as one of the leading countries in Europe in attracting venture capital in clean technology. The bulk of clean technology investment is currently directed at energy generation technologies, where the UK is still attracting most investment in Europe. However, in other sectors such as the emerging clean transport technology, the UK's lead is being eroded by other European countries as well as the recent and growing dominance of the US in the sector.

The analysis, therefore, suggests that venture capital investment, and by extension green business investment, might not be strongly correlated to strong regulatory support or subsidy in particular geographies. Green business investment is rather based on the assessment of rational investment opportunities which will occur wherever there is strong suitable technological specialisation and a strong innovation and entrepreneurial business culture – witness the leading role in cleantech investment currently occupied by the US.

1.2 Introduction

'Green business' is a relatively recent and not well defined term which can be interpreted in different ways by different people and organisations. What is considered green by one organisation may not be by others. Furthermore, the definition of green business is becoming undermined by a proliferation of green labelling and standards which is leading some consumers to consider 'green labels' to simply be a marketing tool with little substance behind it.

Nevertheless, the basic premise of a green business as one which is focused on sustainability, in environmental and resource terms, is well understood by business and consumers alike. While there is a difference in how rigorously that is applied, in practice, the value of labelling a business as green is clear and cannot be ignored, as numerous surveys of consumers and business executives show. In particular, business's decisions to adopt green practices is not purely altruistic or selfless, rather it is based on good business sense – in fact, enhanced profits or revenues are expected to accrue from adopting green business practices.

However, it is important to be able to categorise and measure green business if it is to be encouraged and promoted. This paper proposes a working definition of green business to assess, based on a common understanding, the current and future comparative advantage in green business for the UK economy. We build on existing definitions and broaden these definitions out to reflect the range of opportunities for green business. We then develop a framework to assess green business based on the examination of a business's supply chain.

1.3 What do we mean by green business?

1.3.1 Existing studies

The traditional definition in most studies of environmental markets has focused on the Environmental Goods and Services (EGS) sector which covers activities ranging from pollution control to the development of cleaner processes, environmental consultancy and renewable energy. This definition and related classification of particular sub-sectors (see box 1 below) has been used in the CEMEP report,[3] and by the UK CEED (Centre for Economic and Environmental Development).[4] The European Commission in its study of opportunities for Eco-Industry focused on a very similar list of sub-sectors (see box 2).[5]

Box 1

CEMEP and UK CEED classification of environmental markets

The environmental goods and services (EGS) industry is hugely diverse, comprising a number of sub-sectors, some of which have their roots in some long established sectors, notably in the areas of drinking water supply, waste water treatment, and solid waste management. The sector has expanded significantly as the need for more sustainable products and services has grown and now encompasses high growth activities such as environmental monitoring, renewable energy and clean technologies. Environmental Goods and Services Sub-sectors cover:

- Air pollution control
- Cleaner technologies & processes
- Decommissioning/decontamination of nuclear sites
- Environmental consultancy
- Environmental monitoring, instrumentation and analysis
- Energy management/efficiency
- Marine pollution control
- Noise and vibration control
- Remediation and reclamation of land
- Renewable energy
- Waste management, recovery and recycling
- Water supply and wastewater treatment

[3] Available at http://www.defra.gov.uk/environment/business/commission/pdf/cemep-report.pdf
[4] Available at http://www.ukceed.org/downloads/files/31-DTIEmergingMarketsFullReport.pdf
[5] Available at http://ec.europa.eu/environment/enveco/industry_employment/pdf/ecoindustry2006.pdf

Box 2

EU and OECD definition of Eco-industry

As defined by the OECD and Eurostat, eco-industries are *"activities which produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems. This includes technologies, products and services that reduce environmental risk and minimise pollution and resources."* The sectors fall into two general categories, pollution management and resource management.

Pollution management consists of nine eco-industry sectors:

- Solid waste management & recycling
- Wastewater treatment
- Air pollution control
- General public administration
- Private environmental management
- Remediation & clean up of soil & groundwater
- Noise & vibration control
- Environmental research & development
- Environmental monitoring & instrumentation

Resource management includes five eco-industry sectors that take a more preventive approach to managing material streams from nature to the technosphere:

- Water supply
- Recycled materials
- Renewable energy production
- Nature protection
- Eco-construction

However, as acknowledged in the CEMEP report, *"environmental markets are about much more than just the suppliers of environmental goods and services. There are opportunities for all business, and environmental markets increasingly pervade the whole economy"*. In fact, the report went on to state that *"the transition to a low-carbon, resource-efficiency economy will see the emergence of new technologies and innovations that will stimulate new business models, products and services, transform existing sectors of the economy and create entirely new industries"*.[6]

The Carbon Trust, for example, in its work considers the entire energy sector and those products and services that enter the energy supply chain. The Carbon Trust states that it *"supports innovation in the larger 'ecosystem' of clean energy products and services, not only renewable energy generation. Clean energy companies are those operating within the energy system or supply chain that have the potential to reduce carbon dioxide emissions and other green house gases. Improvements in each of these energy supply chain phases can have system-wide impacts that help to reduce carbon emissions, improve their environmental performance and increase efficiency and productivity for end users"*.[7]

In the context of this study, therefore, we provide a broader definition of environmental markets or 'green businesses'. In discussion with BERR and industry participants, we have thus defined Green Business as "**those business that, across the whole economy, have made efforts to introduce low-carbon, resource efficient, and/or re-manufactured products, processes, services and business models, which allow them to operate and deliver in a significantly more sustainable way than their closest competitors**".

1.4 A framework to assess green business

The purpose of the framework is to identify and codify how businesses incorporate green principles and practices into their business model.

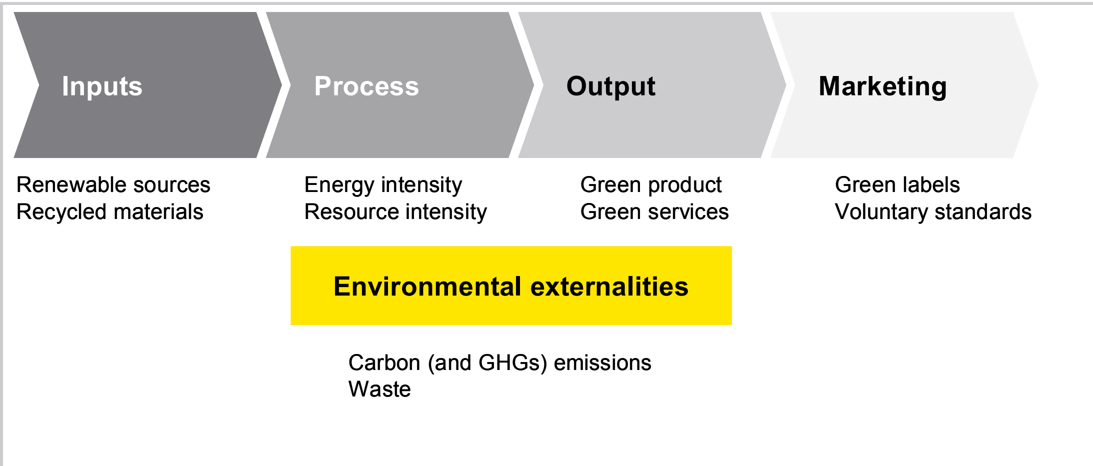
[6] CEMEP report, 2007, page 15.
[7] Available at
http://www.carbontrust.co.uk/Publicsites/cScape.CT.PublicationsOrdering/PublicationAudit.aspx?id=CTC722

1.4.1 Supply chain focus

Our approach is to look at the entire supply chain of a business and the way decisions about green inputs, processes, and products have changed it. In this context, we have identified five key steps in the supply chain: inputs, process, outputs, environmental externalities and marketing.[8] Within this framework we look at how a business adopts green principles in its procurement decisions, operational, sale or purchase activities. To be successfully green, businesses need to not only implement cleaner business practices and, for example, reduce their carbon footprint, but also have better communications with their customers in order to establish their brand and capture market share for green products.

The strategy of a firm is therefore based not only on the concept of productivity but also on the assessment of the life-cycle of products and services. Such fundamental change helps both improve the process by which a product is developed, therefore enhancing a firm's productivity, and change the way a business presents itself to customers, therefore enhancing the reputation and improving services provided to customers. In figure 2 below we show the supply chain approach and suggest for each of the five steps two criteria that can help measure the degree to which a business has adopted green business practices.

Figure 2: Supply chain framework



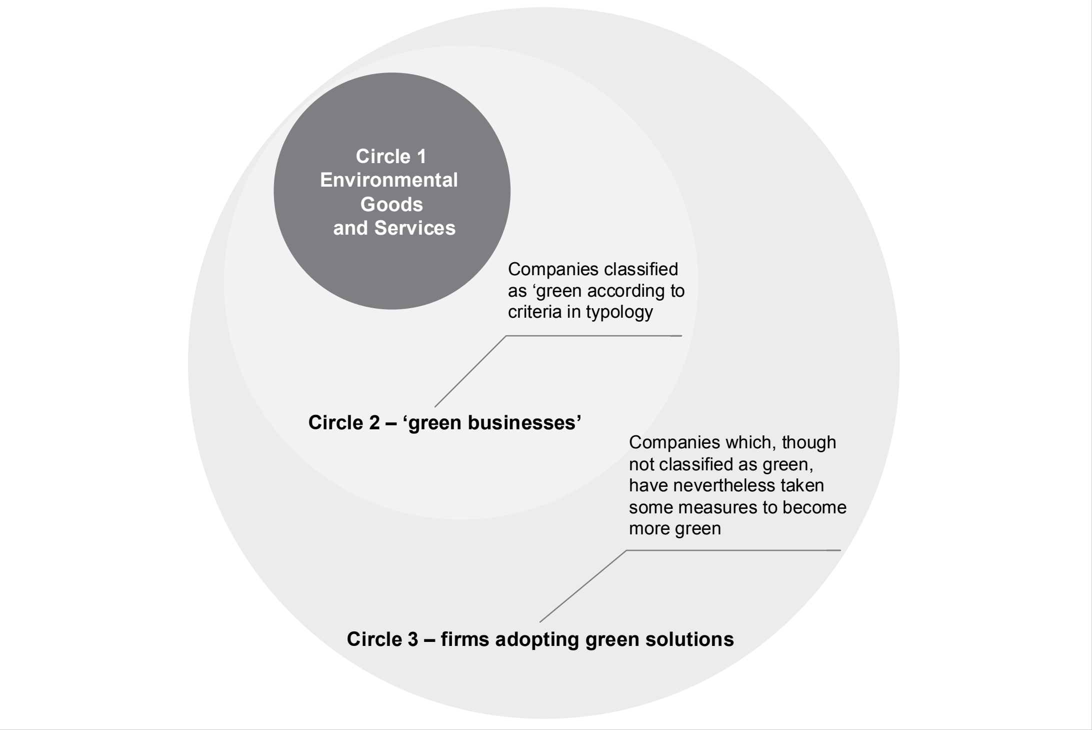
1.4.2 Classifying green business

Using this green business typology and applying the necessary subjective judgement around some of the criteria identified above can lead to the potential scoring and attribution of different degrees of 'greenness' to different businesses. The aim of this exercise would be to sub-divide all businesses of the economy in three broad classifications represented by the circles below:

- Circle 1: Firms whose activity is to produce environmental goods and services (the traditional' 'Environmental Goods and Services' sector)
- Circle 2: Firms which have taken active and identifiable steps to change their products and/or process to take sustainability agenda into account.
- Circle 3: All other firms which have taken some steps to improve process efficiency or change their brand image

[8] Throughout the rest of this study we will use the term 'green business' to capture the broader definition of environmental markets beyond the narrow limits of the environmental goods and services sector

Figure 3: Green business definition



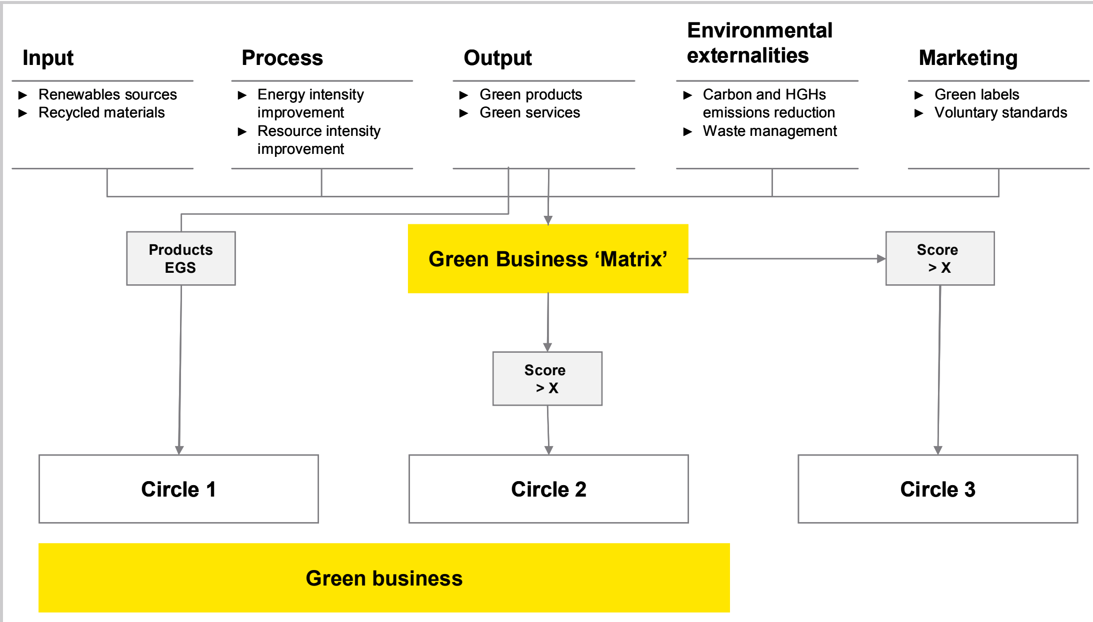
1.4.3 Using the framework for scoring green business

For each of the criteria we identify a particular metric[9]. We would then need to identify a scoring and ranking mechanism that would assign a value of 1 to 5 for each element. The score will reflect the environmental performance of a company across the lifecycle of producing its goods and services. This would then be combined together in a final score – the weighting of the different elements within the supply chain would of course be a key variable. Finally a benchmark for green business would be identified so that if the score for a particular company is higher than the benchmark, then the firm would be classified as green.

The framework for a quantitative assessment of green business would look like the diagram below:

[9] For example for energy intensity, we could use the amount of energy used by a firm in mtoe (million tonnes of oil equivalent) per year over the annual revenue.

Figure 4: Green business framework assessment process



We provide a worked example below for a single company, to illustrate how the above methodology would work in practice. We have chosen to apply the methodology to one of the worlds' leading chemical companies, which has been recognised as a leader in its sector in taking early action with regard to climate change. We have not, as part of this study, applied the methodology to a complete range of sectors or companies, which would be the logical next step in the development of this methodology. In fact, it is not within the scope of this study to provide a detailed collection of all the information and data for the various components of the supply chain related to particular business or to provide an assessment of what the green business threshold or benchmark is. We recognise that a significant amount of work is required to establish a workable set of criteria and benchmarks which can be applied transparently and fairly in practice.

The proposed framework is comparative, so it would rank particular companies or sectors against a benchmark to assess its comparative 'greenness' using a consistent set of metrics which are intended to cover the entire range of activities of the company or sector. The benchmark value for the company or sector can be the industry average, a target set by regulation, or others as appropriate (in our example we have used official national targets for the UK as illustrative benchmarks[10]). Its purpose is to determine, on a consistent basis, whether a company is an outlier (a leader or follower) compared to its competitors. While a certain degree of subjective judgment will need to be applied at each stage of the process, we have nevertheless attempted to make the measurement criteria as numerically based as possible. In this example, which we have based on publicly available sources for the selected company, the score suggests that this company has 'green' characteristics and can therefore be classified as 'green business' according to our previous definition.

[10] For example, we used the 2010 renewable target as benchmark for renewables input; the EU energy efficiency target as benchmark for efficiency; the EU GHG target as benchmark for environmental externalities.

Figure 5: Green business supply chain scoring table example – Leading chemical company

Source: Leading chemical company's accounts and reports, Ernst & Young analysis

	Company performance	Benchmark	Green scoring
Input			
Renewable sources	5.50% with Target of 10% by 2010	10% of energy input	0.5
Recycled materials	n/a	10% of materials input	0
Process			
Energy intensity	47%	20% from 1990 levels	1
Resource intensity	Reduced water use and energy use	20% from 1990 levels	0.5
Output			
Green product	No	Yes	0
Green service	No	Yes	0
Environmental externalities			
Carbon and GHGs emissions reduction	60%	20% from 1990 levels	1
Waste management	52%	20% from 1990 levels	1
Marketing			
Green labels	Subscribe to Global Reporting Initiative Format and Carbon Disclosure Program		1
Voluntary standards	Set internal targets for energy use, carbon emissions, ands renewable energy use		1
Total		5	6

Note: a score of 1 has been given if the stated target is achieved; 0.5 if the target was not achieved but considerable effort was made (for example 50% of target); 0 if target was missed or if the company has no stated target for the area.

1.5 Transition to a low carbon economy – opportunities for green business

The definition of green business we provided above is not, however, a static one. Over time certain businesses that in the current economy are not yet perceived as green, can be expected to become green as they increase their efforts to improve energy efficiency and/or reduce their carbon emissions. In addition, certain sectors, which have not yet adopted green practices across the supply chain, may be expected to increasingly do so over the coming years. On the other hand, sectors which are considered green today may fall behind whilst others may still offer considerable opportunities for further improving energy efficiency and reducing carbon emissions. It is, therefore, the potential prospect for improving resource efficiency or reducing its carbon footprint (both in sectors that would be classified as green today, but particularly in those that would not be classified as green today) that offer the greatest opportunities for the development of comparative advantage in green business.

The CBI Climate Change Task Force in their latest report 'Climate Change: everyone's business',[11] highlighted four areas that offer the biggest scope for carbon abatement in the period to 2030: emissions reduction in buildings (through improvement in residential buildings); power sector; (through use of low carbon technologies such as wind, CCS and nuclear); transport technologies (through improvement in engine efficiency and biofuels use); and industry (through improving manufacturing processes, and using low carbon sources of energy).

[11] Available at http://www.avtclient.co.uk/climatereport/docs/climatereport2007full.pdf

- Emissions reduction in the buildings area can be helped by both a change in domestic energy use but also by the development of new products and services – for example products or services for the design and building of eco-friendly building.

- Low carbon generation technologies such as renewables, CCS and nuclear can help reduce emissions from the power sector. Reduction in power sector emissions will be costly but can yield direct benefits in terms of revenues from tradable permits, and also indirect benefits in terms of new technology exports (the physical technology and also the know-how).

- Transport technologies could provide substantial opportunities for emissions reduction, for example through development of hybrid technologies or biofuels.

- Improvement in the industrial sector will come from the development of new technologies which will allow lower use of energy and lower emissions – such as products used in industrial processes for environmental benefit, including building controls, sensors, components and cleaning products or new materials used in energy products, including nanotechnology, new alloys, thin film, plastics, or chemicals. According to ONS data on sectors energy use and carbon emissions, most sectors have already reduced energy and carbon intensity considerably (manufacturing emissions are down 15% since 1990 and services emissions are down 4.5%), though the potential for further reductions is still significant.

The CBI analysis of the abatement cost curve for the UK estimate the potential savings delivered through these technologies. These measures could deliver around 232mtCO2 by 2030 at a cost of around €40 to €90 per tCO2. This, according to the CBI estimate translates into an investment of around £100 a year per household by 2030 (or just under 1% of GDP).

The potential for emissions reduction is therefore quite significant and so are the costs to move to a low carbon economy (Sir Nicholas Stern estimated around 1% of GDP). However, the investment in green business (or low-carbon, clean technology) will also be considerable, holding opportunities for business that can develop new, clean solutions and capture the increasing demand for it – i.e. in our diagram above, those business who can manage to move from circle 3 to circle 2 ahead of key competitors and therefore gain increased revenue or profit margin through enhanced reputation, experience or leading position in the market. In 2006 alone, for example, the carbon market for EU ETS credits topped €35 billion in terms of trading certificates value,[12] whilst the value of global carbon trading in 2007 was estimated at $60 billion with expectation to reach $200 billion by 2015.[13] Recent estimates put the total investment into renewable generation technologies at around $38 billion (in 2005); investment in biofuels similarly is estimated to have increased to around $38 billion in 2005 from $5 billion in 1995.[14] In some circumstances, geographical location might dictate where investment in abatement or clean technologies will occur (some countries might be better place to invest in wind or solar due to weather condition or in biofuels due to land availability). However, in most cases, the what, where and when will depend on specific government policies and/or business investment decisions.

1.5.1 Investment trends in low carbon and clean technology

To assess the dynamics involved in the shift to a low carbon economy, the trends, and where opportunities in new technologies are likely to develop, we use investment flows data in clean technology[15]. Whilst recent estimates put the total investment into clean

[12] FSA estimate in recent report, "The emissions trading market: risks and challenges", March 2008
[13] EY analysis
[14] The Economist, 28/03/2008.
[15] In the remaining part of this paper we use the term clean tech as proxy for 'green' business. This is to remain consistent with the definition used in the dataset.

technologies at over $45 billion per annum,[16] for our analysis we use a smaller set of the entire investment capital, in particular that of venture capital investment. [17] We make use of venture capital data because is more readily available, and because it offers a very good picture of the size and location of the new clean tech projects at an early stage of development and therefore provides a good indication of the trend in future investment opportunities. In fact, whilst most of the investment in clean technology still comes from corporate investment in large projects, the activity of venture capital market in clean technology provides an indication of the particular products, technology and businesses that are expected to generate high growth and returns. Observing venture capital investment in clean technology can therefore be used as a proxy for determining the type and location of future 'green' opportunities.

We use data from the DowJones Venture One database to present recent venture capital investment activity in the European and American markets. In this context we define Clean Tech as *"products and services that optimise the use of natural resources or reduce the negative environmental impact of their use while creating value by lowering costs, improving efficiency, or providing superior performance."* The type of products and technologies included in the database and defined as clean tech are grouped in categories (annex 1 shows full list of products and technologies included in the database):

- Energy generation
- Energy storage
- Treatment and reuse
- Energy efficiency
- Industry focused products and services

Investments in clean technology are growing globally, led by the United States, and to a lesser extent the EU (figure 6). Total US and EU venture capital investments in clean technology surged to almost US$3 billion in 2007 with the large majority (over 80%) being invested in the US. Venture capital investments overall have also been growing rapidly in recent years and therefore, whilst clean technology is gaining global share among total venture capital investments, the category still remains relatively small. Nevertheless, the sector's share has more than doubled in all regions, led by the US. In 2007, clean tech accounted for about 5.4% of US venture capital investment, and 4.4% of European venture capital investment (figure 7).

[16] Approximately 103 global clean tech deals raised around $49 billion in 2007 (EY analysis)
[17] Venture capital is used as a financial tool for development, particularly for small and medium enterprises (SME) finance, by facilitating access to finance for small and growing companies. It plays a key role in business start-ups, and the growth of existing small and medium enterprises.

Figure 6: Investment in clean tech (US and EU)

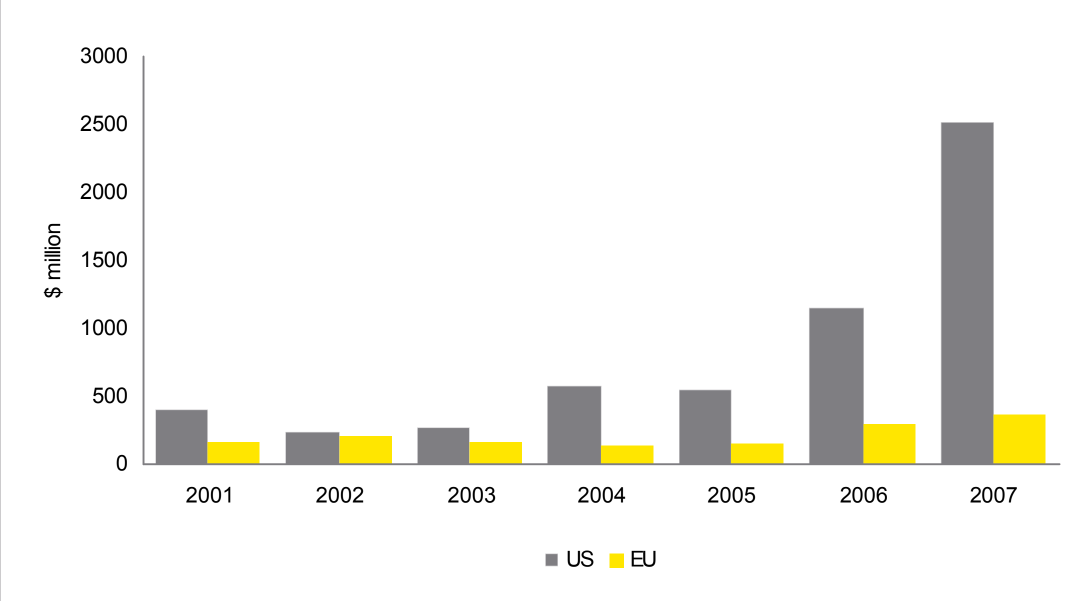


Figure 7: Share of investment in clean tech as a percentage of all venture capital invested

Source: DowJones Venture One

Year	US	EU
2001	1.40%	1.60%
2002	1.40%	1.50%
2003	1.80%	1.80%
2004	2.50%	2.20%
2005	3.00%	1.80%
2006	3.70%	3.50%
2007	5.40%	4.40%

For the clean technology industry to continue to grow there will need to be more sources of capital, specifically from large corporate companies. There are signs that the focus for large corporations has started to shift towards the clean technology with these issues being on the agendas of many CEOs. According to a survey of senior executives (in technology industries) conducted by the Economist Intelligence Unit (EIU), about 61% say that it is very important or important to take measures to reduce or minimise environmental impact[18]. In a separate survey conducted by McKinsey about 60% of global corporations' executives consider climate change issues as important or very important in setting the overall corporate strategy (53% consider it important when making investment decisions).[19] This suggests that, as the importance of environmental factors rise, in particular in policymakers and consumers priorities, other sources of capital are likely to become available to clean technologies which will allow clean tech companies to sustain and strengthen their recent growth in activities.

1.5.2 Clean tech Investment in Europe

As of today, the clean tech market is becoming global in nature, matching the global nature of the climate challenge. North America and Europe will probably remain the primary providers of innovative technology for the near future, but demand will increasingly come

[18] See report "Going green: Sustainable growth strategies*, PWC, 2008
[19] See "How companies think about climate change: A McKinsey Global Survey", McKinsey, 2007

from around the globe. It is thus expected that investment in clean technologies will continue to grow not only in the developed markets but also in the developing markets, mainly China and India.

The United States has become the largest investor in clean technologies over the past three years, with investment focused on relatively late-stage, capital investment in global markets where government intervention is driving demand. The United States' leading position is in large part due to the considerably larger amount of funds that the US capital markets can direct at the sector, but also due to the strength of the high-tech sector, in terms of knowledge base, entrepreneurial skills, and experience of innovation in new technologies.[20]

On the other hand, until 2004, Europe had traditionally been the vanguard of clean tech, with more stringent national and European Union environmental regulation and stronger consumer awareness to green issues. Regulation in particular has been one of the key drivers of the early development of the clean tech sector in Europe. And the government role in the development of clean tech industry has not been limited to the setting of regulation; the market for investment in early-stage of development products is in fact dominated by government-backed funds. According to a study by Library House and Carbon Trust, the public sector participates in 45% of all clean tech deals in the United Kingdom and 15% in the rest of Europe.[21]

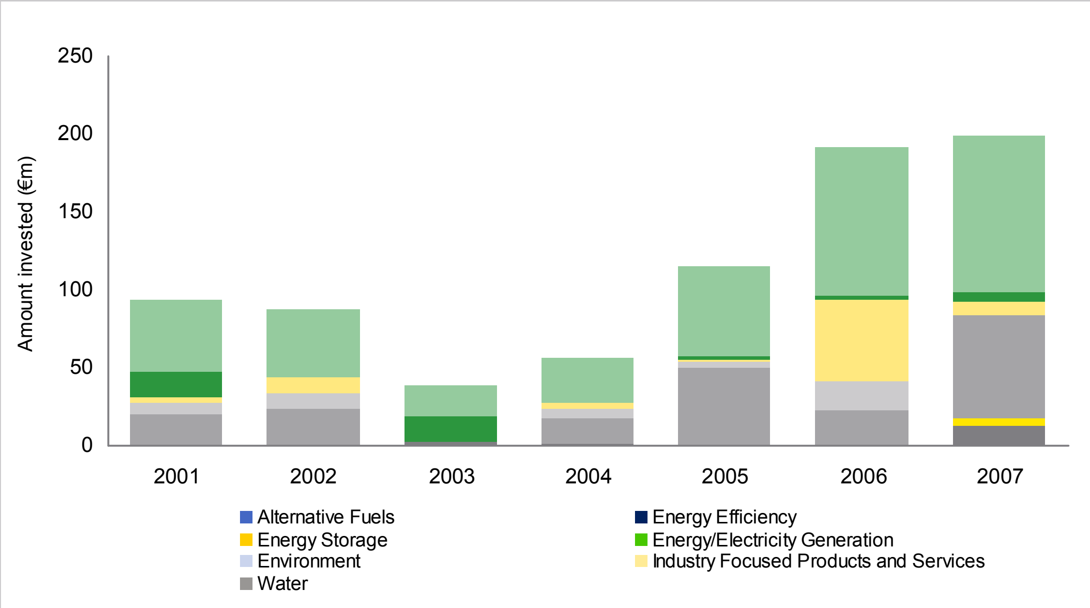
However, over the past three years Europe has fallen behind the US both in the number of clean tech deals and the amount of investment in the sector. Nevertheless, and although Europe hasn't shown the same growth curve in clean technology investment as the US, investment in the sector in 2007 has exceeded 2006 levels. Based on the VentureOne database of projects, in 2007, venture capital investors injected more than US$200 million into 19 European companies.

Over recent years, investment has been channelled primarily to energy generation technologies. Data shows that in the EU energy generation technologies have accounted for around 37% of the invested capital in clean technologies (between 2001 and 2007). There has been, however, a large rise in investment going into industry focused products and services. In 2007 capital invested in industry focused products and services increased by €58 million (250%) to €81.1 million, meaning it accounted for 30% of the total amount invested during the year. Figure 8 shows the relative proportions of different investment segments between 2001 and 2007.

[20] The experience of the California clean tech boom is an example of the importance of clusters and transferable experience (from other high tech sectors) – see paper 3 for more details.
[21] See "Cleantech goes mainstream", Library House, 2007

Figure 8: European Clean Technology Investment by segment

Source: DowJones Venture One



In the energy generation sector, solar activity has been historically strongest, accounting for 67% of the €99 million invested in 2007 (see figure 9) - this area was dominated by German companies due to the attractive regulatory environment aimed at growing the German solar industry. An analysis of industry focused products and services show that the investment in different sub-categories has varied considerably in recent years. However in 2006 and 2007 there has been a distinct trend towards investment in transportation. In the most recent data for 2007, 91% (€74 million) of the total investment in the sector was involved in transportation clean technology (primarily focused around development of components for hybrid and electric cars).

Figure 9: European Clean Technology Investment in energy generation

Source: DowJones Venture One

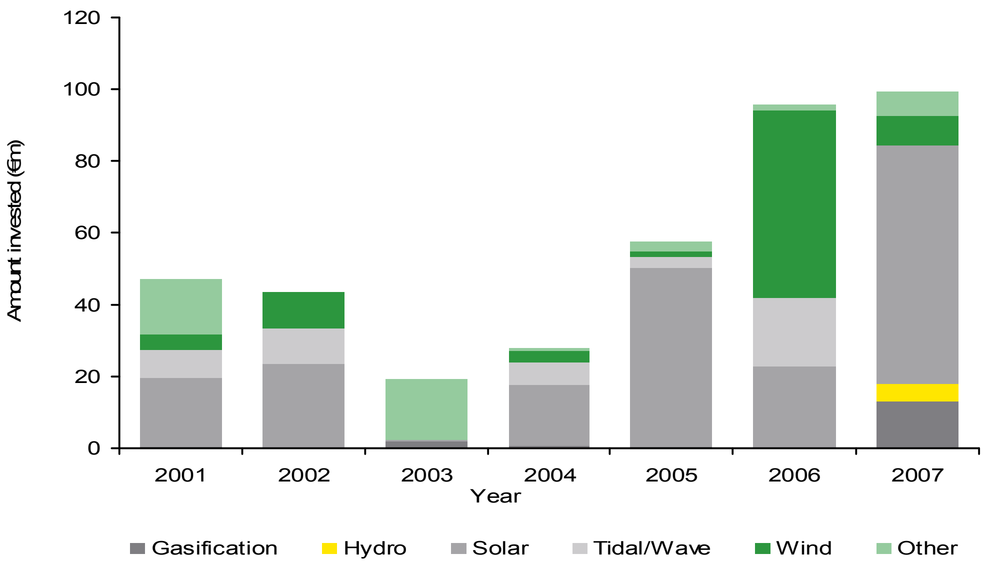
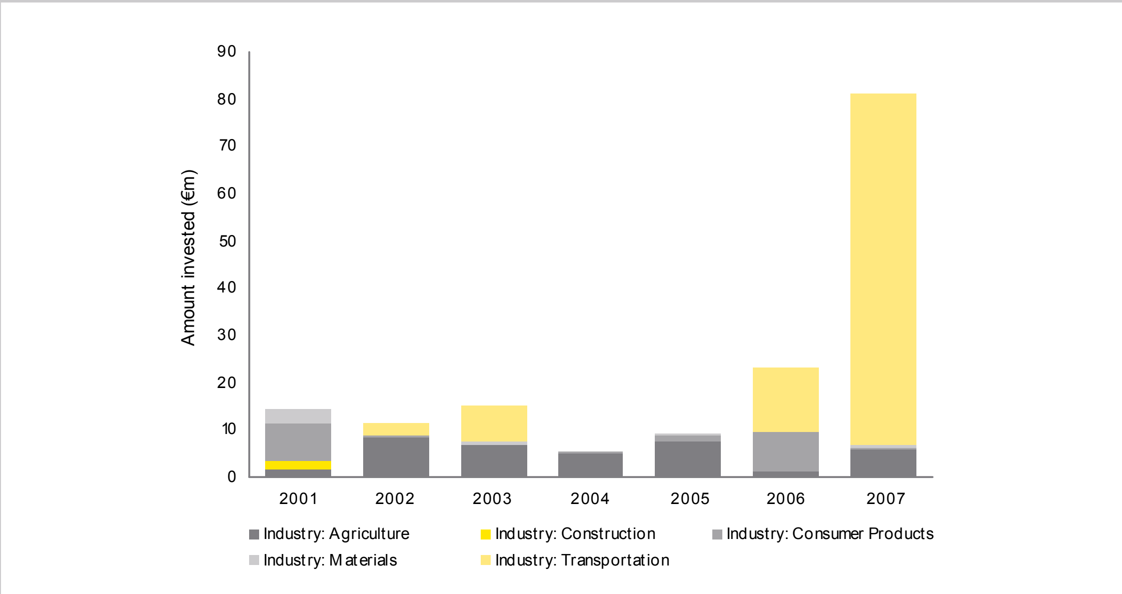


Figure 10: European Clean Technology Investment in industry

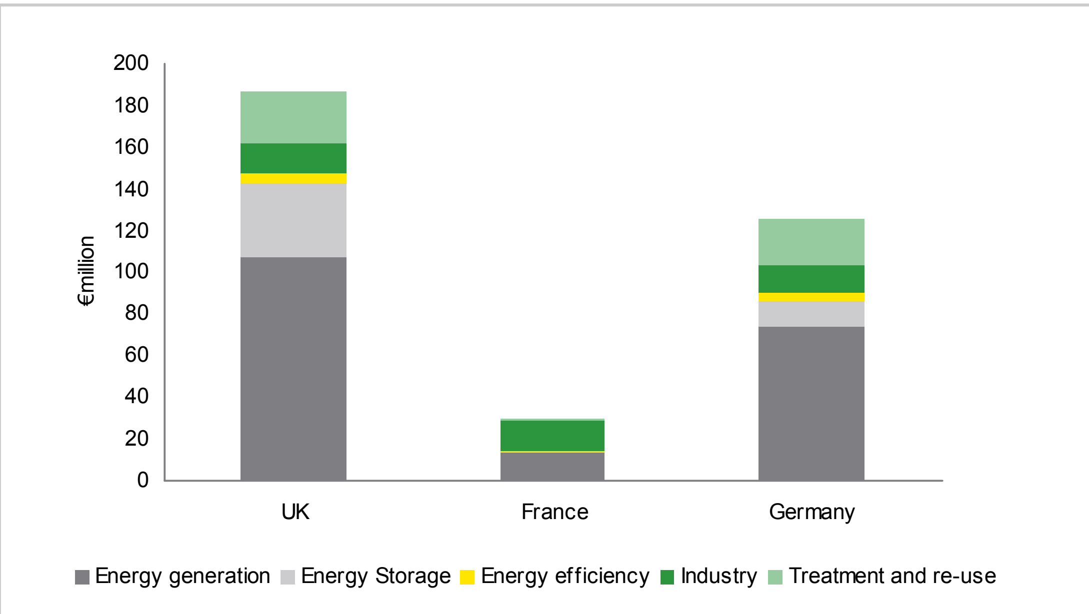
Source: DowJones Venture One



1.5.3 Clean tech investment in the UK

The UK, Germany and France host the largest numbers of clean technology companies in Europe that are supported by venture capitalists (see figure 11 below). The UK hosts 34 private venture capital backed clean technology companies with a cumulative €186 million invested in them. Germany follows with 25 companies with €123 million of cumulative investment. For France, the figures are 12 companies with €30 million invested. The UK does however seem to be lagging in clean transportation projects and also in clean tech industrial products.

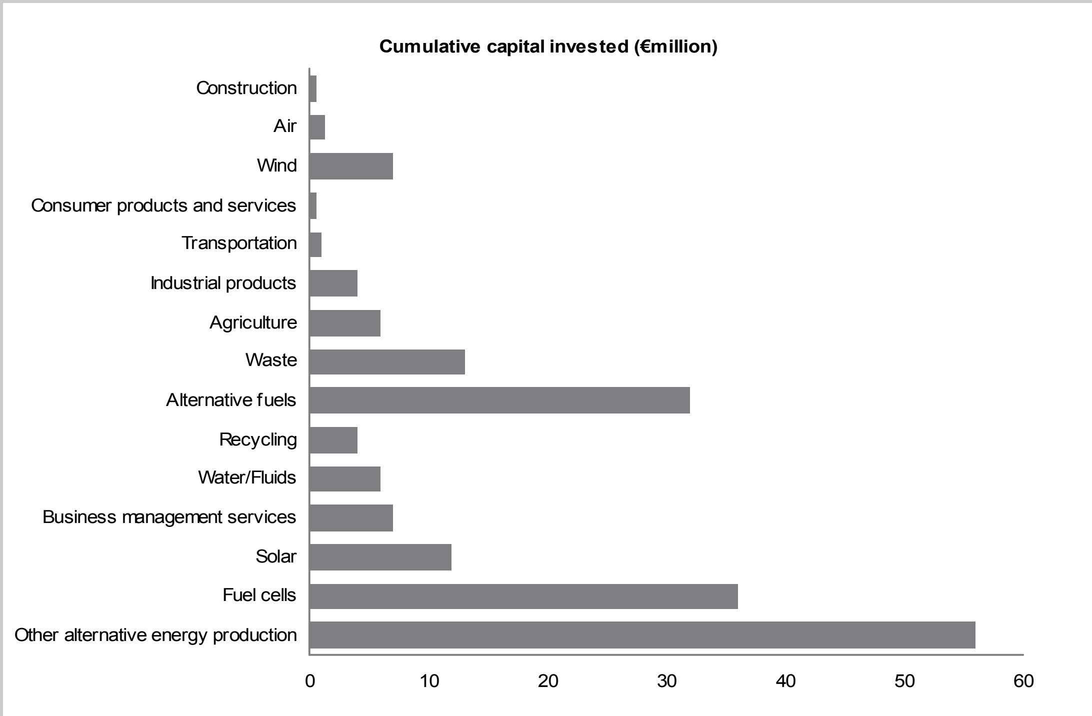
Figure 11: European Venture capital clean technology Portfolio



In the UK, the largest clean tech venture capital market in Europe, the focus has been on generation and energy storage technologies and alternative fuels. One of the key reasons of success for the UK has been the strength of its financial sector, which allows easy access to capital, and the creation of clusters of activity around both key companies' headquarters and key scientific centres located in high quality universities.

Figure 12: UK Private clean technology Portfolio (2007)

Source: DowJones Ventureone



In fact, numerous studies have shown that clusters, classically in Silicon Valley, Boston (USA) or Cambridge (UK), are instrumental in the growth of new industries. The Carbon Trust in their report, 'Investment trends in UK clean technology 2000-2004', identified mini-clusters around the standard UK technology hotspots, i.e., London, Cambridge, Oxford, Southampton, Bristol, Cardiff, Chester/Manchester, Newcastle/Middlesbrough, Aberdeen and Edinburgh. Around 18% of clean tech companies in the UK originate from UK universities, the largest number coming from Cambridge, Imperial College, and Cardiff.

1.5.4 Conclusion – Future outlook

Based on our framework, we showed that there are opportunities for green business in many sectors of the economy. The typology we identified can help classify business from those that are already actively taking action to capture such opportunities to those that have taken less or little action yet. This does not imply that such business or sectors yield no opportunities for the development of green products and services. In fact, the analysis of a particular class of green products, those classified as clean tech, shows that there are investment opportunities in many sectors which are not traditionally associated with green products (for example, in construction, materials or industrial products, such as sensors or cleaning components) Overall though, the analysis show that the majority of investment in clean tech products is still concentrating in two areas: energy generation and transportation/fuels – though investments have also gone into products and materials along the supply chain for energy generation and transportation projects.

Overall, the analysis of venture capital investment points to a rapidly growing market (more than 30% annual growth), increasingly dominated by investment in the US, which has rapidly and extensively outstripped Europe in terms of investment available – despite the different regulatory environment in place (currently more favourable in Europe). It is important to note that difference in the financial market structure is also responsible for the larger amount of venture capital investment in the US compared to Europe and therefore the amount of funds available to invest in the general high-risk investment in small, technology-based firms, which are often passed over by traditional financial institutions.[22]

Nevertheless, venture capital investment in clean tech is increasing in Europe as well, with electricity generation technologies attracting the bulk of the investment. Alongside the energy generation sector, the industry products sector, particularly in relation to transport technologies, is the fastest growing areas. Therefore, in the near future technologies aimed at producing low-cost sustainable fuels will continue to attract investment. Similarly investment in alternative generation technology, including wind and wave power, will continue to grow.

Based on the current pattern of clean tech investment in the UK, it seems that the UK could be well placed to take advantage of such opportunities, as it has attracted the most of such venture capital investment amongst EU countries in the past five years (see UK share in table below). In 2007 alone, the UK attracted about 30% of all European Clean Tech investment. The areas that are most likely to receive attention are alternative electricity generation technologies, including wind but particularly wave and tidal power, and energy storage technologies such as fuel cells.

Finally, the analysis of venture capital investment suggests that green business investment might not be strongly correlated to strong regulatory support or subsidy in particular geographies. Green business investment is rather based on the assessment of rational investment opportunities which will occur wherever there is strong suitable technological specialisation and a strong innovation and entrepreneurial business culture.

Figure 13: European Venture capital investment in clean tech product (2001-2007)

	Capital invested (€m)	UK Share (%)	Trend (growth over 2005-2007)
Electricity generation	390	19.2%	49.9%
Energy efficiency	44	18.3%	50.1%
Energy storage	147	24.4%	12.1%
Transportation	178	18.5%	278.2%
Industrial products	62	16.1%	39.8%
Recycling	170	10.7%	20.2%
Water	50	11.9%	30.2%
Total investment	1044	17.8%	42%

[22] In fact, among the OECD countries, the venture capital industry is most well-established in the United States, where it is oriented to technology-based sectors and consists of a range of investors, including pension funds, insurance companies and private individuals. In the more highly regulated European market, the venture capital industry is younger, oriented to mainstream rather than high-risk sectors and dominated by banks. The creation of secondary or over-the-counter stock markets for small, growing companies is also important to the supply of venture capital. See *Regulatory Reform And Innovation, OECD paper*

1.6 Annex 1

Clean technology investment definition

Clean technology category definitions

Energy generation	Energy storage
► Alternative fuels – The manufacture and production of fuels including ethanol, bio-diesel and liquefied natural gas (LNG). ► Other alternative energy production – including tidal/wave technologies, biogas, hydrogen, clean coal, geothermal technology, hydro, and others. ► Solar –includes photovoltaic (PV), thin film solar, crystalline silicon on glass (CSG), wafers, solar water and air heating systems, copper indium diselenide (CIS), silicon-ink cells, iridium cells and manufacturing equipment. ► Wind – power generation from wind, mainly turbines.	► Batteries – battery technology that is rechargeable, increases storage, increases life cycle, decreases lead or is recyclable, often used in environmentally friendly vehicles. ► Fuel cells – Innovations in fuel cell technologies **Treatment and reuse** ► Air – includes air purification and emission reduction ► Recycling – re-use of old materials, including computers, asphalt, paper, boxes, lube oil, batteries, mobile phones, packages and contaminated wood. ► Waste – processes to treat and manage waste products, including in-situ thermal desorption (ISTD), waste and plasma gasification, offshore waste processing, and decontamination. ► Water – processes for the purification, treatment, remediation and irrigation of water
Energy efficiency	**Industry-focused products & services**
► Energy efficiency products – reduce emissions, increase efficiency or store energies that emit pollutants. ► Power and efficiency management services ► Industrial products – products used in industrial processes for environmental benefit, including building controls, sensors, components and cleaning products	► Agriculture – products and services used in growing food, feed and ethanol crops. ► Construction – products and services for architectural design and building of eco-friendly buildings. ► Materials – new materials used in energy products, including nanotechnology, new alloys, thin film, plastics, chemicals, metals, fabrics, quartz, plasma and packaging. ► Transportation – technologies focused on clean vehicles, including hybrid electric drive systems, exhaust purification and engines. ► Consumer products & services – direct to consumer products and services. ► Environmental testing & analysis: products and services for all types of sampling, testing and measurement of environmental targets.

2. Paper 2: Assessing the UK comparative advantage

2.1 Executive summary

We identify in this paper eight key sectors where the UK has comparative advantage, based on trade data supported by analysis of foreign direct investment flows. These sectors are software, electronic equipment, business services, financial services, machinery equipment, aircraft, chemicals and pharmaceuticals.

We also assess whether there are opportunities to develop comparative advantage in green business where no such advantage currently exists. We cite the example of the Scroby Sands offshore wind farm where nearly 50% of contract value was UK sourced, but where subsequent wind farms UK content has fallen to some 15-25%. We find that artificial stimulus of comparative advantage in green business where none exists tends to be unsustainable without continuing, and often increasing, government and regulatory support.

Finally, by combining analysis of these sectors with the identification of clean technology trends in paper 1, we identify five sectors where the UK currently exhibits comparative advantage and could develop green business opportunities in specific sub-sectors; software, electronic equipment, business services, financial services, and machinery equipment.

In addition to the five sectors identified above, other sub-sectors have the potential to demonstrate comparative advantage. However, further work is required to define clearly these sub-sectors and their current and potential comparative advantage. We recommend further, more detailed, sub-sector analysis to identify specific areas of long term comparative advantage and consider ways in which to enable their more rapid transition to becoming low carbon, resource efficient green businesses.

2.2 Introduction

The structure of the economy will change over coming decades as governments, regulators, companies and consumers in the UK and internationally take action to reduce carbon emissions. To meet this challenge, businesses will need to change their approach and take concrete steps to improve efficiency and reduce emissions, whilst consumers will increase their demand for products that are more efficient and less carbon intensive. This will involve costs as new technologies are developed but also opportunities in terms of efficiency savings and in terms of the development of new products to meet the growing demand for low-carbon products. The UK wants to be well placed to benefit from such opportunities. We therefore need to identify where and in which sectors the UK currently has a comparative advantage compared to its major competitors.

The first step is to define the concept of comparative advantage.

The next step is to determine the measures by which we will assess comparative advantage. In this paper we use two different measures:

- Revealed Comparative Advantage (RCA), using data on international trade in goods.
- Investment flows, using a dataset of foreign direct investment projects.

The final step is to use the data to review and assess the sectors in which the UK holds comparative advantage, and understand the opportunities for the development of low-carbon sectors.

2.3 Definition of comparative advantage

Comparative advantage is a well-established concept in the analysis of international trade. A country possesses a comparative advantage when it is able to produce a good at lower cost, relative to the costs of other goods, than is the case in other countries. The key aspect of this concept is the cost relativities for different goods within a country rather than the absolute levels of production costs as compared among countries. For example, even in the case where a country has a higher cost structure for all products, it will still possess a comparative advantage in any product where the cost of production relative to other products is lower than in other countries.

There are a wide range of factors that can give rise to comparative advantage. These include the relative availability of resources or skills; the application of technology; economies of scale or even proximity to market. Comparative advantage can also be enduring, for example as in the case of technology leadership, or transitory, as in the case of learning from competitors.

2.4 Revealed comparative advantage

Whilst there are different methods to calculate or estimate comparative advantage (and below we mention a few metrics), one approach we have adopted to examining comparative advantage is through the calculation of revealed comparative advantage. This calculation is based on national and world trade data and relates the share of a good in a country's total exports to the share of that good in total world exports. In other words a country has a revealed comparative advantage in the production of a good if the good in question accounts for a greater share of that country's total exports than the share of total world exports accounted for by that good. We used 2006 International Trade Centre (UNCTAD/WTO) trade data to look for sectors in which the UK enjoys comparative advantage. Annex 1 provides more detail on the dataset and metrics used. [23]

2.5 UK's comparative advantage in goods producing sectors

In our assessment of comparative advantage we considered four different criteria: size of exports (to assess a sectors' relative importance for the UK economy), net trade position (i.e., whether exports are larger than imports), rate of growth of world export trade for the sector (to assess future potential market size and therefore sectors' future opportunities), and the 'Balassa specialisation index' which is the equivalent to the calculation of Revealed Comparative Advantage (RCA) described above. However, in the process of identifying the key sectors where the UK has comparative advantage the two main criteria employed are the 'specialisation index' and the size of exports.

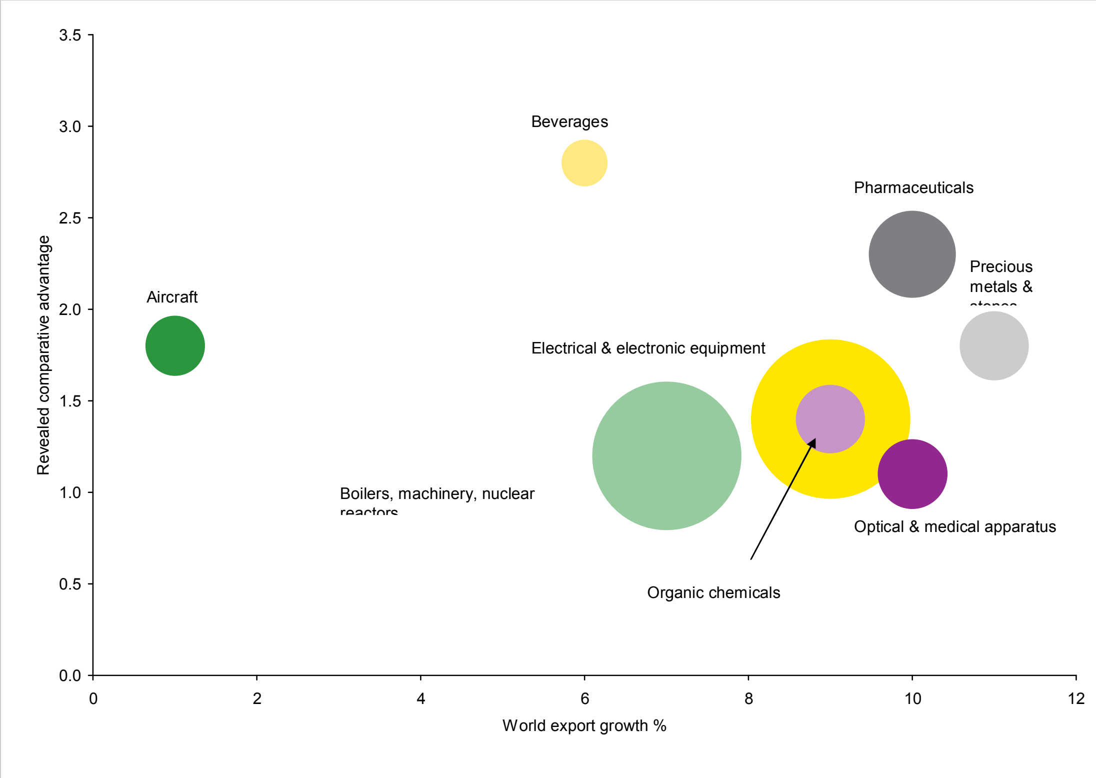
We looked at all sectors included in the International Trade Centre (ITC) database for those where the RCA value is above 1 (showing comparative advantage). Figure 14 below shows 8 out of 27 goods producing sectors [24] in the UK which have a bigger share of total UK exports than these same sectors have within total world exports (specialisation index is higher than 1) and where annual exports are in excess of £1bn. The chart sets out 3 aspects of the UK's trade performance for goods producing sectors where the UK possesses a revealed comparative advantage and where the value of exports in 2006 exceeded £4bn.

[23] Whilst we do acknowledge that using Revealed Comparative Advantage concept as a metric suffers from some limitations, we believe it provides a reasonable indication of one country's relative competitive position against its key trading partners. See annex I for more details.

[24] The data are sourced from the UNCTAD/WTO International Trade Centre database. See http://www.intracen.org/menus/countries.htm

Figure 14: The UK's comparative advantage in goods

Source: International Trade Center (UNCTAD/WTO)



- The y-axis shows the result of the revealed comparative advantage (or specialisation index) calculation. The index value for each sector is represented by the centre of its circle on the chart. [25]
- The x-axis shows the rate of growth of export volumes at the global level over the 2002-2006 period, with the centre of the individual circles representing the sector's growth rate. World trade is estimated to have grown by 9% over the same period.
- The size of each sector's circle represents the value of its exports in 2006.

Specialisation does not, however, necessarily indicate that the sector makes a positive contribution to the UK's net trade position, or a large contribution to total trade. Of the sectors identified in the chart only Electric & electronic equipment (£11.4 billion), Pharmaceuticals (£7.7 billion) and Organic chemicals (£0.7 billion) make a positive contribution to the UK's net trade. The trade deficit on Aircraft is £3.6 billion, compared with exports of £11.6 billion, while that on 'machinery equipment' sector (boilers, machinery, nuclear reactors) is £1.0 billion. The beverages sector scores the highest on the revealed comparative advantage index (2.8), but the value of UK exports from this sector in 2006 (£4 billion) is relatively small compared with those of the electrical & electronic equipment sector (£82 billion) and the Machinery sector (£72 billion).

With the exception of the aircraft sector all sectors where the UK enjoys comparative advantage seem to be relatively fast growing sectors in world trade – implying the potential for further opportunities.[26] Figure 15 below summarises key trade indicators for such sectors, which highlight that, with the exception of pharmaceuticals (where the UK share is

[25] See annex 1 for explanation of the Balassa or 'specialisation' index.
[26] The fastest growing sectors in world trade in which the UK scores highly on revealed comparative advantage indices are Precious metals & stones (11% per annum growth between 2002 and 2006), Pharmaceuticals (10% growth per annum) and Optical & medical apparatus (10% growth per annum).

however increasing), all these sectors are in rapid expansion on a global scale (providing therefore further opportunities for exports).

Figure 15: Key sectors where UK has comparative advantage

Source: International Trade Center

Industry	Specialisation (Revealed Comparative Advantage)	Net trade ($m)	Exports in value ($m)	Growth of world exports in value (% p.a.)
Pharmaceutical products	2.3	7,690	24,417	-3
Aircraft	1.8	-3,642	11,634	8
Electrical, electronic equipment	1.4	11,411	81,958	16
Organic chemicals	1.4	725	15,455	16
Boilers and machinery	1.2	-1,046	71,719	14
Optical and medical apparatus	1.1	-511	15,731	17

When put against its main OECD competitors the UK scores particularly high in the electronic equipment sector. Its exports performance (as expressed by the specialisation index) is better than any of the other European and North American OECD countries – only East Asian countries (including Japan and South Korea) perform better. On the other hand the UK is behind USA and France in the aircraft sector and scores lower than Italy, Japan, the USA and Germany in the Machinery sector (see annex 2 for more information around sectors' data).

The combination of the data analysed above suggests that the sectors where the UK enjoys comparative advantage and which offer the greatest potential export opportunities are those high tech, capital intensive manufacturing sectors such as pharmaceuticals, optical and medical instruments, electronic equipment and chemicals. According to ITC classification, all these sectors can be considered 'high tech sectors' (and are also more capital intensive than the average industrial sector) – see figure 16 below.

Figure 16: Stage of processing for key comparative advantage sectors

Source: International Trade Center

Industry	Share of high tech products (%)	Share of primary (%)	Share of intermediates (%)	Share of capital (equipment) (%)	Share of consumer goods (%)
Pharmaceutical products	26.9	0	8.2	0	91.8
Aircraft	0	0	63.6	36.4	0
Electrical, electronic equipment	62.1	0	24.1	68.6	7.4
Boilers and machinery	34.1	0	58.5	40.7	0.7
Optical and medical apparatus	56.6	0	20.2	64.7	15.1
All industries	21	9.3	38.9	23.3	23.9

We have also looked at data results for some of other traditional key non high-tech manufacturing sectors to observe UK's relative performance in these sectors and validate our conclusion. According to both the net trade position and the Balassa specialisation index, the UK does not seem to enjoy a strong comparative advantage in such sectors (with a low high tech component). This highlights the relative comparative advantage the UK enjoys in capital intensive and high tech products.

Figure 17: UK trade performance for selected sectors

Source: International Trade Center

Industry	Specialisation (Revealed Comparative Advantage)	Net trade ($m)	Exports in value ($m)	Share of high tech products (%)	Share of primary (%)	Share of intermediates (%)	Share of capital (equipment) %	Share of consumer goods (%)
Automotive	1	-25,252	37,483	0	0	22.3	13.4	64.3
Plastics	0.8	-4,059	11,318	1.6	0	84.1	0	15.9
Iron and steel	0.8	2,103	9,437	0	23.2	76.8	0	0
Articles of iron or steel	0.8	-1,737	5,933	0	0	89.7	7.8	2.5
Cement	1	-173	1,257	0	0	100	0	0

2.6 Investment flows

A different measure to assess the relative comparative advantage of the UK against its major competitors is to look at foreign investment flows data. We observe the movement in international investment amongst major developed countries to determine the sectors in which the UK is attracting more investment. The data is taken from the 2007 Ernst and Young European Investment Monitor (EIM).[27]

2.6.1 Foreign Direct Investment (FDI) projects dataset

The EIM database shows that over recent years there has been a consistent increase in investment into Europe. In 2006 there were 3531 investment projects recorded showing a 15% increase on 2005. The UK is the leading recipient of FDI in Europe. In 2006, there were 686 investment projects in the UK which was 19.5% of the total number of European investments. Although there has been a trend of the UK market share declining in recent years the actual projects in the UK in 2006 grew by 23% meaning that market share increased to 19.5% from 18.2%.

Figure 18: FDI projects in Europe

Source EY European Investment Monitor, 2007

		Number of FDI projects n 2006	Market share 2006 (%)	Number of FDI project 2005	Evolution of number of projects 2005/2006
1	UK	686	19.4%	559	22.7%
2	France	565	16.0%	538	5.0%
3	Germany	286	8.1%	182	57.1%
4	Spain	212	6.0%	147	44.2%
5	Belgium	185	5.2%	179	3.4%
6	Poland	152	4.3%	180	-15.6%
7	Romania	140	4.0%	86	62.8%
8	Switzerland	136	3.9%	93	46.2%
9	Czech Republic	113	3.2%	116	-2.6%
9	Sweden	113	3.2%	95	18.9%
11	Hungary	108	3.1%	115	-6.1%
12	Netherlands	95	2.7%	82	15.9%
13	Russia	87	2.5%	111	-21.6%
14	Ireland	74	2.1%	67	10.4%
14	Italy	74	2.1%	49	51.0%
	Other	505	14.3%	466	8.4%
	Total	3,531	100.0%	3,065	15.2%

[27] The Ernst and Young's European Investment Monitor Report identifies the clear trends and changes in investment decisions and is therefore able to highlight key sectors with a comparative advantage.

With regard to job creation, FDI activity resulted in the creation of a record 211,000 jobs in Europe in 2006, an increase of 8.3% on the previous year. Available employment data indicate that Western Europe in general was characterised by investment in a large number of projects that were less labour intensive; a factor undoubtedly linked with the higher staff costs in the region. The number of jobs created increased in most of the 15 European FDI destinations. At a national level, the UK and France remained second and third respectively in terms of job creation, although the number of jobs created declined slightly (27,000 jobs created in the UK and 20,500 in France).

Figure 19: FDI job creation (2006)

Source EY European Investment Monitor

	Countries	Total job creation in 2006	Market share of job creation 2006 (%)
1	Poland	31,115	14.7%
2	UK	27,481	13.0%
3	France	20,509	9.7%
4	Czech republic	17,369	8.2%
5	Romania	13,969	6.6%
6	Slovakia	13,527	6.4%
7	Hungary	10,906	5.2%
8	Spain	9,970	4.7%
9	Germany	9,893	4.7%
10	Portugal	9,816	4.6%
11	Ireland	7,153	3.4%
12	Russia	6,960	3.3%
13	Belgium	5,417	2.6%
14	Serbia	5,212	2.5%
15	Bulgaria	4,080	1.9%
	Other	17,996	8.5%
	Total	211,373	100.0%

2.6.2 Sectors specialisation

With regard to sectors specialisation, the investment flows data portrays a picture very similar to that illustrated by the trade data. The UK retains a clear leading position in Europe in terms of investment in services and high tech products: business and financial services, software, pharmaceuticals, and electronic equipment.

Figure 20: Investment Projects by sector and by country in 2006

Source: EY European Investment Monitor

	Belgium	France	Germany	Poland	Spain	United Kingdom	Other	Total
Software	11	72	19	8	29	167	167	**473**
Business Services	18	74	41	13	21	128	150	**445**
Electronics	8	37	32	13	8	48	88	**234**
Machinery & Equipment	18	58	24	12	10	26	79	**227**
Financial Services	11	12	14	4	12	41	101	**195**
Automotive Components	7	21	10	15	15	12	88	**168**
Chemicals	21	19	20	8	13	19	64	**164**
Other Transport Services	14	24	15	10	11	20	54	**148**
Pharmaceuticals	10	17	12	2	5	30	54	**130**
Food	8	15	8	8	6	15	58	**118**
Other	60	216	91	59	82	180	541	**1229**
Total	**186**	**565**	**286**	**152**	**212**	**686**	**1,444**	**3,531**

In the electronic and the machinery sectors, over the past couple of years (since 2005) the UK has seen strong competition for investments coming from other major European countries (particularly France and Germany). Nevertheless, over time the UK has still attracted more investment in both these areas and it is still the preferred location for investment in Europe for business services and headquarters services. Further analysis of the dataset for sectors in the UK is in Annex 3.

2.7 Comparative advantage and green business

Analysis of opportunities for green business, particularly the analysis around clean technologies investment[28], showed that energy generation is the sector attracting the largest investment in clean technology, and amongst those sectors, solar and wind are the two key technologies. To check UK's comparative advantage in this particular sector and the implications for the UK economy and potential jobs creation, we looked at an example of offshore wind project to see how much of the supply chain is actually captured by the UK.

2.7.1 Scroby Sands offshore wind project – level of UK content in project's supply chain

With the award of licences to develop offshore wind energy, the UK created one of the world's largest current market places for the deployment of marine renewable technology. With billions of pounds worth of capital required to realise over 7GW of electrical capacity, a significant opportunity has been presented to develop a strong UK supply chain supporting this emerging industry. We take the Scroby Sands offshore wind project to assess the level of UK content in the project's supply chain and therefore infer some conclusions around the actual potential implications from developing such opportunities.

The Scroby Sands offshore wind farm, located an average of 3km off Caister, was developed by EROWL (formerly Powergen Renewables Offshore Wind Ltd). It obtained planning consent in 2002 and construction began in 2003. The development, construction and initial five years operation of the Scroby Sands offshore wind farm resulted in a total expenditure of £80 million. Contracts to the value of £38.8 million (48%) were sourced from UK companies[29]. The highest levels of UK content were realised within the

[28] See paper "Definition and characteristics of green businesses"
[29] Scroby Sands - Supply Chain Analysis, Renewables East, DWL Report Number 334-04, July 2005

development and operations phases of the project. Whilst the values for UK contracts were relatively high, the derived man-hours were higher, as the majority of support activities, such as environmental monitoring and surveys, were almost entirely UK based, reflecting the low value-added of the UK input. Certain areas such as the ongoing operations and maintenance have created new jobs which will be sustainable and of benefit in the long term to the local economy.

Figure 21: Scroby Sands project - investment required and source (£'000s)

	Total	East of England	Other UK	UK %
Procurement & manufacture	38,986	8	16,821	43%
Offshore Installation	16,700	283	1,940	13%
Project Management	4,551	2,201	2,175	96%
Onshore Pre-Assembly	2,200	1,614	230	84%
Commissioning	2,175	613	978	73%
Onshore Installation	1,825	1,825	0	100%
Insurance/Legal	1,779	211	1,568	100%
Development Design	1,409	149	780	66%
Operations & Maintenance	6,825	5,095	550	83%
Transport & Delivery	1,225	55	235	24%
Detailed Design	1,111	180	156	30%
Other Misc. Costs	838	202	486	82%
Surveys	260	248	12	100%
Environmental Monitoring	190	162	28	100%
Total	80,073	12,844	25,957	48%

The primary areas of the Scroby Sands project which appeared to be less open to UK penetration centre on the construction phase. Within the construction phase of Scroby Sands contracts to the value of approximately £71.5 million were awarded of which £31.9 million was sourced from UK suppliers. The primary area in which the UK seemed to lack capability was within activities related to the manufacture and installation of blades and nacelles – of a total spend of £28.6 million just £3 million of such activity was catered for within the UK. However, UK suppliers were heavily involved in the onshore pre-assembly, commissioning and operation and maintenance of all components, resulting in the level of UK content rising from 45% of the value of construction phase contracts to 70% of the associated hours incurred. An analysis of the contracts awarded within Scroby Sands shows that UK content could conceivably have been raised from £38.8 million (48%) to £56.5 million (71%) given current capability and assuming competitive tenders. The primary area of potential growth was offshore installation, where it is believed UK companies could have performed the installation of all the key components of the development. Therefore the only area of significant weakness remains the manufacturing of nacelle and blades which account for £22 million of the differential between UK potential value and the total value of Scroby Sands.

The level of UK content for Scroby Sands was nevertheless considered to be relatively high and set a benchmark for future projects. More recent wind farm UK content has fallen to below an estimated 25% of total value. The existing supply chain within the UK has the capability to support the majority of activity inherent within the development, construction and operation of an offshore wind farm. However, it is likely that the supporting supply chain will not fully emerge until the market develops further and more projects are actually commissioned. Indeed, the level of UK content will largely be a function of the timing and positioning of the development of the national supply chain.

Supply chain issues in the wind energy market are becoming increasingly important, as the sector experiences annual rates of growth approaching 20%. Continuing supply chain constraints for turbine manufacturers throughout the supply chain present potential opportunities for UK manufacturing sectors to consider this market. Furthermore, the recent investment by The Crown Estate in Clipper Windpower's development of a very large offshore turbine (7.5MW) in the UK is an example of the opportunity available to leap frog technological developments in response to local demand drivers from the UK market.

We can preliminarily conclude from this example of a sector where the UK enjoyed little comparative advantage, that it appears more difficult to develop comparative advantage rather than leveraging existing comparative advantage to develop green business opportunities. Specifically, although up to 50% of the value of offshore wind farms can be sourced within the UK, this tends to be the lower value add portion for which no natural comparative advantage applies. Although there may be opportunity for further development of UK comparative advantage in this sector, it is clear that unless comparative advantage is gained in certain sectors due to either supply side factors (e.g. constraints in the supply chain) or demand side factors (e.g. UK offshore wind sector requiring larger machines more quickly that elsewhere) then attempts to artificially create it at this point in the supply chain could be highly expensive and probably unsustainable.

2.7.2 Comparative advantage in clean tech products

How can we expand this analysis to other sectors and how can we apply this particular approach to the trade data we used to assess UK comparative advantage? The analysis of an offshore wind farm above showed that the supply chain involves many different components and therefore might touch quite a different set of industrial sub-sectors. The clean tech data (which we use to identify the low-carbon technologies opportunities) and the International Trade Center database (which we used to identify comparative advantage) are, however, different in terms of sectors coverage and classification, therefore it is not straight forward to assess which sectors or sub-sectors exactly match Clean Tech products.

We would need to further disaggregate the trade and investment data into sub-sectors and look for those which we believe will contain clean tech products. However, a precise mapping of the relationship between trade sub-sectors and clean tech products (and therefore the assessment of clean tech products performance in terms of exports size, and specialisation index) is a complex exercise which is beyond the scope of this work.

In this section, we present only a working example for two of the sectors where the UK has comparative advantage. Further work will be needed to make a more detailed and robust assessment of comparative advantage in clean tech products.

2.7.2.1 Sub-sectors analysis – the example of the electronic equipment and machinery sectors

The analysis of trade data and foreign direct investment flows pointed to a few sectors where the UK has comparative advantage (both in terms of trade and investment flows); in addition to the financial and business services sectors, these are electronic equipment, pharmaceutical, aircraft and machinery equipment sectors. We only looked into the details of two of these sectors – electronic equipment and machinery equipment. Annex 2 shows more in detail the results of the analysis.

There are approximately 49 sub-sectors in the electronic and 86 in the machinery equipment sector. Within these, not all the sub-sectors show comparative advantage – only about 7 in the electronic equipment sector and 18 in the machinery sector show both a score higher than 1 in the specialisation index and an exports value higher than a £1billion (our definition of comparative advantage); furthermore, within these sub-sectors not all will be relevant for clean tech products. Figure 22 below summarises the key sub-sectors where the UK has comparative advantage according to trade data and where we have identified those that are relevant for clean tech products (Annex 2 provides full details of the sectors disaggregation)

According to the analysis of sub-sectors trade data, within the electronic sector the key sources of comparative advantage comes from the television, radio and radar apparatus, which provide little opportunity for clean tech products. Within the machinery sector, the production of propellers, turbines and heavy machinery for transportation seems to provide the largest contribution to the positive position of the sector in terms of comparative advantage. Within these sectors there are opportunities for companies investing in clean products to exploit the UK comparative advantage position. In particular, what emerges from the trade data therefore is that the UK seems to have comparative advantage in those sectors that could be able to assist and support the development of clean tech products in the energy generation and energy storage technologies. On the other hand, it seems to be lagging behind in those sectors that could provide support to transportation and industry-focused clean tech products (with only the possible exception of aircraft design).

Figure 22: Sub-sectors comparative advantage and clean tech products

Source: International Trade Center

Industry sub-sectors	Type of clean tech sector	Specialisation	Net trade ($m)	Exports in value ($m)	Prospects for growth
Boilers and machinery, of which:		**1.2**	**-1,046**	**71,719**	
Turbo-jets, turbo-propellers and other gas turbines	Energy generation: turbines. Transportation: aircraft propellers	5.3	7,647	15,417	M
Engines, spark-ignition reciprocating or rotary int. combust. Piston	Energy generation; industry (energy efficient machinery)	2.1	1,915	2,771	M
Electrical, electronic equipment, of which:		**1.4**	**11,411**	**81,958**	
Electric generating sets and rotary converters	Energy generation; industry (e.g. turbines, blades for wave projects)	2.9	1,176	1,564	H
Electrical app for switching	Energy generation and transmission; metering and switching technology	0.8	-538	2,033	M

2.7.3 Comparative advantage in services sectors and green opportunities

From the analysis of investment flows – based on the European Investment Monitor – the UK emerged as the leading destination for foreign investment in services. In particular over the past 10 years the UK has attracted the largest number of investments in financial, business and communications services (more than 25% of total projects in Europe), as illustrated by figure 23 below.

Figure 23: Services sub-sectors and clean tech service/product

Source EY European Investment Monitor

Sector	Number of projects in the UK (1997-2006)	Share of total European projects	Type of clean tech or 'green' service
Business services	532	28.4%	Environmental consultancy services; environmental marketing
Transport and communication services	337	18.3%	Energy efficient buildings; more efficient use of data centres; remote communications; old equipment recycling schemes; Transport procurement policy – more efficient engines
Financial services	243	26.4%	Investment in carbon trading; carbon offsets; green or clean tech indices; socially responsible investment funds; providing capital for investment in clean tech and environmental products/projects
Retail services	106	25.7%	Energy efficient buildings; hybrid or biofuels powered trucks; eco-friendly product offerings/promotion
Recreation	38	36.2%	n/a
Education and health	17	34.7%	n/a
Construction	12	11.8%	n/a
Other services	1293	34.7%	n/a

Whilst overall, in terms of emissions reduction potential, the service sectors offers smaller opportunities than the manufacturing or domestic sector, business and companies in the service sector are still responding to climate change and are active in the development of new and greener products/services. In fact, according to a survey of our major clients about 50% of companies in the service sector are providing products/services with green or clean tech features.[30] Figure 23 above provides some examples of types of green services. The largest opportunities appear to lie with the financial services and transport and communication services – both areas in which the UK has over the past 10 years outperformed other European countries in terms of attracting new investments.

2.8 Conclusion

Our analysis of trade and investment data showed that the sectors which have performed best in terms of trade performance and investment attraction, and therefore we qualify as enjoying a 'comparative advantage', are high tech manufacturing sectors and business/financial services. In particular, within manufacturing: software and electric & electronic equipment; aircraft; pharmaceuticals, chemicals, and precision (optical and medical) instruments; and within services: business services and financial services.

The key characteristics that provide advantage to the UK seems to be the ability to attract capital (presence of strong financial markets – and therefore many venture capital investment funds), the supply of high quality services to start and promote a new business (strong software and business/management services), and the presence of a sophisticated and high tech manufacturing base.

Are these sectors relevant for low-carbon, clean-tech business?

A more detailed analysis of the sectors and sub-sectors shows that they are particularly relevant in relation to low-carbon (clean tech) business and we can already see activities on the part of key large companies to promote clean technologies and clean products. The

[30] Ernst and Young proprietary information

UK is well positioned to gain from development of clean tech products particularly in the software and electronic sector, and business and financial services. It has also the potential to benefit from the developments in the machinery equipment sector (especially those machineries linked to electricity generation technologies) and to a lesser extent in the aircraft sector. Figure 24 below summarises the potential and opportunities from such sectors.

Figure 24: Sectors where UK has comparative advantage

	Relevance for low-carbon or clean tech	Type of clean tech product	UK comparative advantage	Opportunity for clean tech in the UK
Financial services	High	Investment in carbon trading; carbon offsets; green or clean tech indices; socially responsible investment funds; providing investment capital in clean tech and environmental products/projects	Key destination for investment and capital Skilled workforce London cluster	High
Boilers and Machinery	High	Energy generation components (e.g. turbines) and industrial equipment	UK enjoys comparative advantage in key sub-sectors. UK leads investment in clean generation technologies such as marine	High
Software	High	Energy efficient data centres Energy/Data management software	UK is primary destination for software investment. South East England act as a key cluster	High
Electronic equipment	High	Energy efficient electrical components and electrical appliances	UK is leading exporter and investment destination. High tech and capital intensive sector.	High
Aircraft	Medium	Efficient engines, turbines	UK is a net exporter. Capital intensive sector. Leading manufacturer based in the UK	Medium
Business services	Medium	Efficiency management services. Environmental consultancy services; environmental marketing	Key destination for investment and capital Strong skills base in related and transferable activities (e.g. consultancy, media, legal etc.)	High
Chemicals	Low	New compounds for plastics and other (building) materials; cleaning products. Waste treatment chemicals. Enabler for fuel cells development	UK is a net exporter.	Medium
Pharmaceuticals	Low	n/a	UK specialised in high-tech and end-consumer goods. Leading investment in Europe	Low

The analysis in this section has been focused on the sectors and sub-sectors where the UK has comparative advantage and the potential for stimulating green products and services in these areas. We recommend further, more detailed, sub-sector analysis to identify specific areas of long term comparative advantage and consider ways in which to enable their more rapid transition to becoming low carbon, resource efficient green businesses.

2.9 Annex 1

Revealed Comparative Advantage methodology and data sources

We used 2006 International Trade Center (UNCTAD/WTO) trade data to look for sectors in which the UK enjoys comparative advantage.

ITC provide comprehensive statistics on international trade (imports and exports) for 261 product groups (of the Standard International Trade Classification SITC Rev.3), and for more than 170 countries over the period 2001 to 2005 – data is taken from the COMTRADE database of the United Nations Statistics Division (UNSD). The database we used considered exports and imports for 97 different manufacturing goods sectors.

In our assessment of comparative advantage we considered four different criteria: size of exports (to assess a sectors' relative importance for the UK economy), net trade position (i.e., whether exports are larger than imports), rate of growth of world export trade for the sector (to assess future potential market size and therefore sectors' future opportunities), and the 'Balassa specialization index'. This index is calculated by UNCTAD/WTO based on data from 2002 to 2006. An index value of 1 for a sector indicates that over that period the share of the UK's goods exports represented by the sector is equivalent to the sector's share at an aggregate world level. An index value in excess of 1 therefore identifies a sector that make up a greater share of UK exports than it does at a world level, so identifying a sector in which the UK specialises, with the greater the difference in the index value from 1 the greater the degree of specialisation. Equivalently, an index of below 1 identifies sectors in which the UK is under-represented in export trade.

The Balassa index is, in the terminology used by the International Trade Center (UNCTAD/WTO), equivalent to the Revealed Comparative Advantage concept described above – a country has a revealed comparative advantage in the production of a good if the good in question accounts for a greater share of that country's total exports than the share of total world exports accounted for by that good.

Revealed comparative advantage, while helping to describe current or past trading patterns, suffers from a number of potential drawbacks as an analytical tool. For example, RCA does not explain what gives rise to comparative advantage – factors such as resource endowment; technology; skills, position within the global value chain etc. And RCA is not a dynamic measure, but only offers a snapshot of past trading conditions. Thus it may not be a good basis for predicting future trading patterns where change is driven by the introduction of new products, the adoption of new technologies or high levels of foreign direct investment.

Therefore, whilst we do acknowledge that using Revealed Comparative Advantage concept as a metric suffers from some limitations, we believe it provides a reasonable indication of one country's relative competitive position against its key trading partners.

2.10 Annex 2

Sectors disaggregation

Industrial sub-sectors and clean tech

The table below summarises the key sub-sectors of sectors where the UK has comparative advantage according to trade data and which clean tech products therefore could benefit from it. There are approximately 49 sub-sectors in the electronic and 86 in the machinery equipment sector. Within these, not all the sub-sectors show comparative advantage – only about 7 in the electronic equipment sector and 18 in the machinery sector show both a score higher than 1 in the specialisation index and an exports value higher than a £1 billion (our definition of comparative advantage) figure 25 below. Furthermore, within these sub-sectors not all will be relevant for clean tech products.

Figure 25A; Sector disaggregation – electronic equipment sector

Source: International Trade Center

Industry sub-sectors	Type of clean tech sector/product	Specialisation (Revealed Comparative Advantage)	Exports in value ($m)	Prospects for growth
Electronic equipment, of which:				
Television camera, transmission appliances for radio-telephony	n/a	H (5.2)	44,311	M
Electric generating sets and rotary converters	Energy generation; industry (e.g. turbines, blades for wave projects)	H (2.9)	1,563	H
Recorded tape, recorded for sound	n/a	H (2.5)	2,320	L
Radar apparatus, radio navigational appliances & radio remote control apparatus	n/a	H (2.4)	1,014	M
Electric app for line telephony	n/a	M (1.5)	4,129	M
Prepared unrecorded media for sound record (tapes)	n/a	M (1.3)	1,103	H
Electrical machinery & appliances having individual function	n/a	M (1.2)	1,459	M
Electrical app for switching	Energy generation and transmission; metering and switching technology	L (0.8)	2,033	M
Television receivers (including video monitors & video projectors)	n/a	L (0.7)	1,968	H
Diodes/transistors & semiconductor devices; etc	Industry	L (0.6)	1,573	H
Electric transformer	Energy generation and transmission	L (0.6)	1,153	L
Part suitable for use with televisions	n/a	L (0.5)	1,911	M
Insulated wire/cable	Energy generation and transmission; cabling for electricity network and large infrastructure, e.g. offshore wind	L (0.5)	1,233	M
Electronic integrated circuits and micro-assemblies		L (0.4)	5,540	M

Note: Prospect for growth is based on an assessment of current growth trend in UK export and growth trend in world exports

Figure 25B: Sector disaggregation – boilers and machinery sector

Source: International Trade Center

Industry sub-sectors	Type of clean tech sector/product	Specialisation (Revealed Comparative Advantage)	Exports in value ($m)	Prospects for growth
Boilers and machinery equipment, of which:				
Turbo-jets, turbo-propellers and other gas turbines	Energy generation: turbines. Transportation: aircraft turbines	H (5.3)	15,416	M
Fork-lift trucks	n/a	H (3.1)	1,505	M
Machinery for sorting/screening etc.	n/a	H (2.5)	1,165	H
Engines, spark-ignition reciprocating or rotary int. combust. Piston	Energy generation and industry	H (2.1)	2,770	L
Self-propelled bulldozer	n/a	H (2)	2,697	M
Machinery part	n/a	M (1.5)	2,825	H
Centrifuges, including centrifugal dryers; filtering/purifying machinery	n/a	M (1.3)	1,635	M
Diesel or semi-diesel engines	Transportation; efficient clean cars	M (1.2)	1,794	M
Parts & accessory of computers & office machines	n/a	M (1.1)	8,699	M
Tap, valve for pipe, tank for the like	n/a	M (1.1)	2,109	M
Part for use solely/principally with the motor engines	n/a	M (1.1)	1,998	M
Pumps for liquids; liquid elevators	n/a	M (1.1)	1,486	M
Automatic data processing machines, optical reader, etc	n/a	M (1)	11,048	L
Air, vacuum pumps	n/a	M (1)	1,649	L
Machines & mechanical appliances having individual functions	n/a	L (0.6)	1,378	L

Note: Prospect for growth is based on an assessment of current growth trend in UK export and growth trend in world exports

According to trade data therefore the UK seems to have comparative advantage and therefore to be able to profit primarily from products in the energy generation or energy storage technologies.

Trade Performance Index (TPI)

The International Trade Centre provides very detailed sector disaggregation of trade data. It breaks down trade data in 100 sectors, though each sector can also be further split down in many different sub-sectors – for example the electronic equipment sector is divided in 47 sub-sectors. The ITC also aggregates up sectors in large 'macro'- sectors and for such sectors has developed the Trade Performance Index (TPI) with the aim of assessing and monitoring export performance and competitiveness by sector and by country.

Generally, trade performance is characterised by rough indicators, such as the level of openness (total trade in goods and services divided by GDP) or growth of exports over a given period. Departing from the rough indicators referred to above, microeconomic and generally qualitative indicators are used to characterise the competitiveness of nations. It appears that the relative position of a country or product on the international market, and its development over time, is a good indicator of competitiveness. Trade statistics capture these changes and have the advantage of being available for a substantial number of countries. For those countries which do not report trade statistics, their trade profile can be (partially) completed by using mirror statistics. Lastly, trade data is broken down at the industry and product levels, which provides a disaggregated insight into trade performances. On this basis, developing countries can be ranked according to their trade performance, based on various criteria. A ranking can be provided by country, sector, or a combination of different criteria.

For each country and each sector, the TPI provides indicators on a country's general profile, on a country's position and on the decomposition of the country's change in world market share. Altogether, the TPI consists of 22 quantitative indicators of trade performance.[31] The key indicators of performance here considered are:

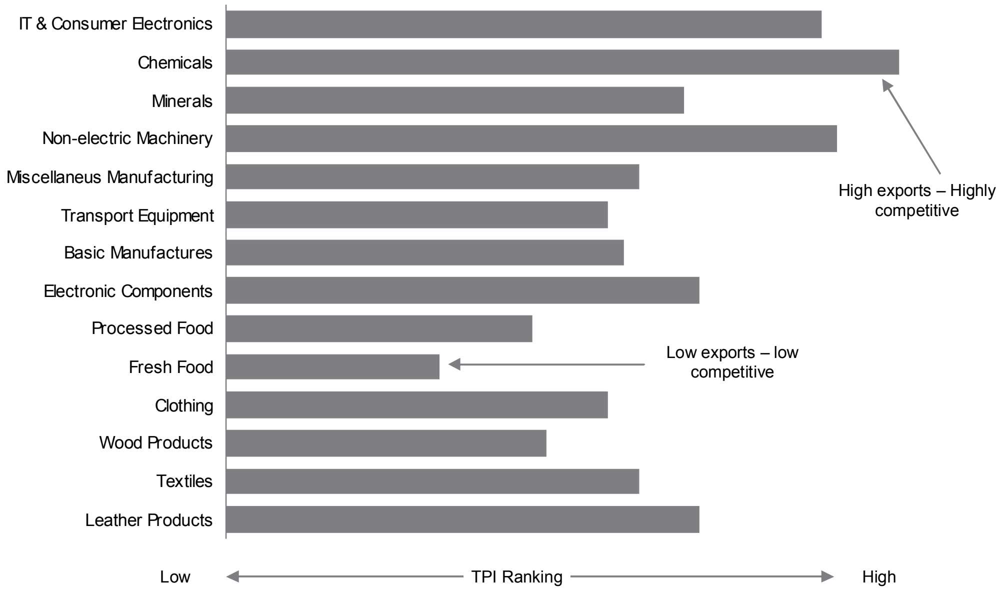
- Value of net exports
- Per capita exports
- Share in world market
- Product diversification and concentration
- Market diversification and concentration

In addition to these indicators, the TPI includes a composite index (CI), which is based on a simple average of the five rankings of indicators described previously. The composite index reflects the position of a country in a given sector for a given year, in terms of trade performance. Changes over time of this position reflect improvements or deterioration in trade performance of the country under analysis. The chart below illustrates the UK ranking for each of the 14 sectors. The sectors are ordered by size of exports (largest exports value first, smallest last), whilst the bars show the ranking in the aggregate TPI for the UK – longer bar reflect higher ranking (position 1 in the ranking refers to the best performance out of 189 countries).

[31] The raw trade data using for calculating the indicators are defined at the 6-digit level of the Harmonized System, 1996 edition, which includes more than 5'000 product items. The data are extracted from COMTRADE (http://comtrade.un.org), the United Nations Commodity Trade Statistics Database, maintained by the Statistics Division of the UN.

Figure 26: Trade Performance Index (United Kingdom)

Source: International Trade Center



The TPI therefore confirms results from trade data outlined above, pointing out the key sectors where UK currently holds comparative advantage: IT and electronics and electronic components, chemicals, and other machinery.

2.11 Annex 3

Sectors disaggregation – investment data

With regard to sectors specialisation, the investment flows data portrays a picture very similar to that illustrated by the trade data. The UK retains a clear leading position in Europe in terms of investment in services and high tech products: business and financial services, software, pharmaceuticals, and electronic equipment.

Figure 27: Investment projects by sector and by country in 2006

Source: European Investment Monitor (EIM)

	Belgium	Czech Republic	France	Germany	Hungary	Poland	Russia	Spain	Sweden	United Kingdom	Other	Total
Software	11	8	72	19	5	8	4	29	18	167	132	**473**
Business Services	18	14	74	41	7	13	1	21	15	128	113	**445**
Electronics	8	9	37	32	6	13	5	8	8	48	60	**234**
Machinery & Equipment	18	8	58	24	10	12	2	10	2	26	57	**227**
Financial Services	11	4	12	14	7	4	9	12	7	41	74	**195**
Automotive Components	7	17	21	10	14	15	3	15	3	12	51	**168**
Chemicals	21	2	19	20	9	8	9	13	3	19	41	**164**
Other Transport Services	14	2	24	15	2	10	1	11	5	20	44	**148**
Pharmaceuticals	10	3	17	12	2	2	2	5	6	30	41	**130**
Food	8	4	15	8	6	8	7	6	2	15	39	**118**
Other	60	42	216	91	40	59	44	82	44	180	371	**1229**
Total	**186**	**113**	**565**	**286**	**108**	**152**	**87**	**212**	**113**	**686**	**1023**	**3531**

Over the last eight years software has been the leading sector in terms of foreign direct investment in the UK – and the main reason why the UK has remained at the top of the FDI table. US software company investment is the most important flow of FDI project in Europe. Similarly, business services investment (it includes business process outsourcing, administrative activity, shared service centers and the provision of customer support) has seen rapid growth since 1997. It accounted for 12.6% of all investment projects in Europe in 2006, and has been showing a growing trend of overseas investment.

Figure 28a: FDI projects in software services

Source: EIM

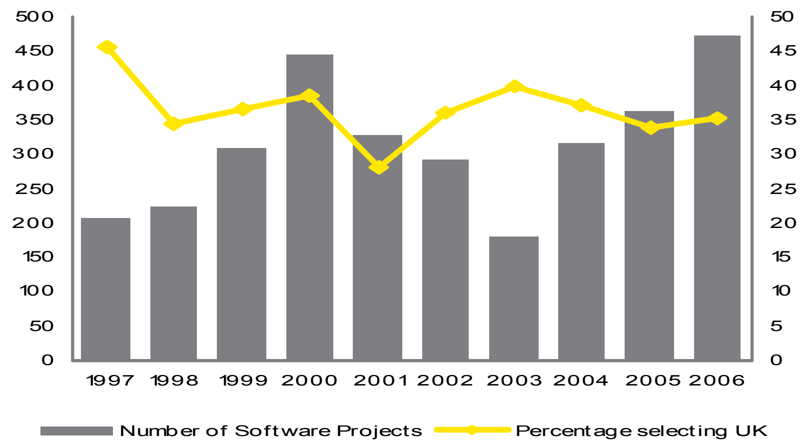
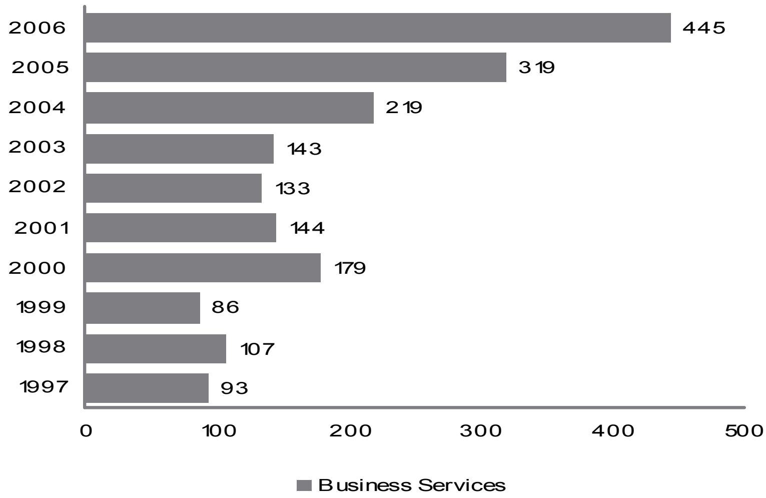


Figure 28b: FDI projects in business services in the UK – ten years trend (1997-2006)

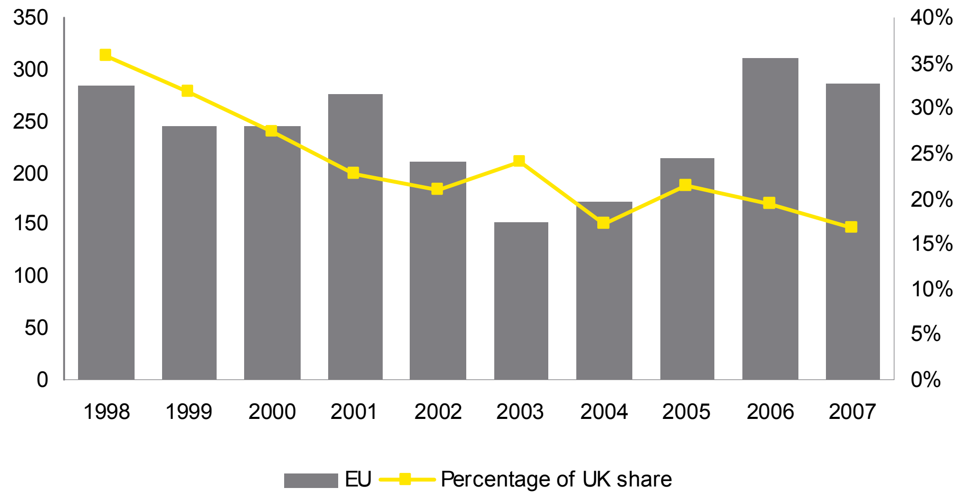
Source: EIM



Investment in the electrical and electronics sector has increased recently and whilst the UK share of such investment has declined since the late 90's, the UK still maintains a leading position in Europe.

Figure 29a: Electrical and electronic equipment

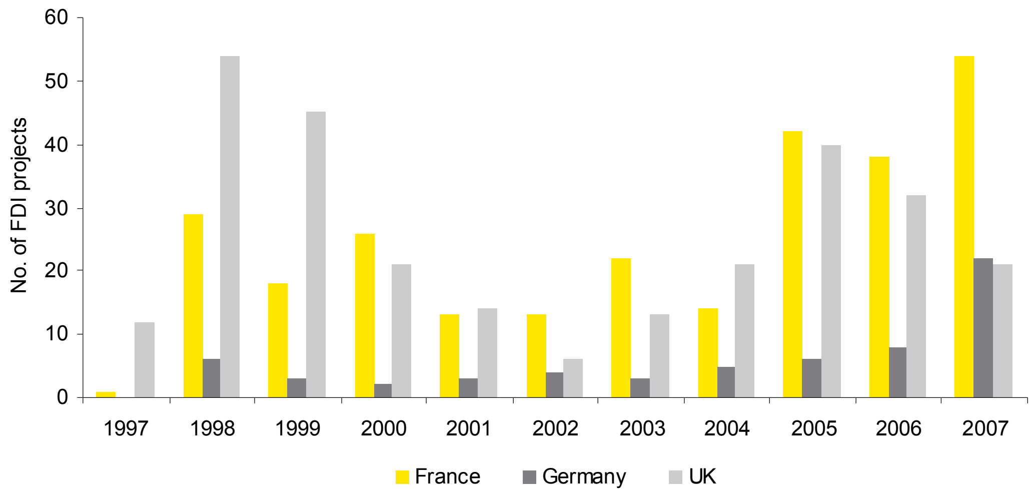
Source: EIM



Similarly in the machinery sector, the UK is still leading in terms of overall investment projects, but has seen its share eroding considerably under strong competition from France and more recently Germany.

Figure 29b: Machinery investment (1997-2007) for key European countries

Source: EIM



Over time the UK has still attracted more investment in both these areas and it is still the preferred location for investment in Europe for business services and headquarters services.

3. Paper 3: Characteristics of successful green business models

3.1 Executive summary

We assess here the characteristics of successful green business models within the UK and worldwide and identify the key drivers. The analysis of the key activities identified within the case studies has in fact highlighted a number of key factors that have facilitated the success of the sectors or companies. The analysis suggests that the trigger and driver for a company or sector to become green (i.e., develop low-carbon or clean tech products) comes from demand side factors, either through regulation or through a change in consumer behaviour; more specifically, in many cases, the anticipation of a change in regulation or consumer behaviour was a key driver of change. However, the key necessary *success factors* that enable businesses to successfully respond to such drivers seem to lie on the supply side, in creating the right conditions for the investment in and development of low carbon, resource efficient products. There is also evidence to suggest that while demand and supply side factors act together and reinforce each other to create specific successful green businesses such as in the Danish wind sector, in future the twin effects of global competition and adoption of green products and services beyond first mover markets, may make the support of supply side factors dominant over the demand side.

3.2 Case studies

We have looked at a relatively large sample of different case studies to demonstrate examples of comparative advantage in action, though we have considered for a more detailed assessment only a limited number of cases. These have been selected with the aim of providing a balanced selection of examples covering a variety of different sectors and industries, from the UK and internationally. This selected sample of cases is illustrative of activity taking place in the global economy, and the purpose of the exercise has not been to try and cover all companies active in this area or all sectors of the economy. Macro cases were selected to demonstrate the wider effect at a regional or national level, whilst the remaining 'micro' cases (at a company level) examine activities within specific companies. In Annex 1 we include some of the 'macro' examples of successful cases at a regional and national level. Both the service and manufacturing sectors are examined in the various sectors, and following on from our original definition of green business the focus is broader than just the traditional environmental goods and services industry, although this is also covered.

The focus of the case studies analysis is to consider companies covered by the cases, and to extract learning in terms of the activities that led to the successful outcomes where the companies gained a comparative advantage through a focus on low carbon resource efficient activities.

The analysis of the success factors identified within the case studies has highlighted a number of recurring factors that have facilitated the success of the sectors or companies, which are summarised in the next section.

3.3 Green business model success factors

The analysis of the case studies, both at a corporate (individual business) and institutional (national, regional and local government) level, has highlighted six key factors that have facilitated success in applying a low carbon, resource efficient business model. Four of these factors are what we would call supply side factors; we recognise that these factors are not necessarily (or exclusively) 'green' – they do not apply only to successful green business model, but they are also at the base of most high technology and high innovative business models. In addition to these first four factors there are two that we call the key driving factors of green business – these factors are those that differentiate, incentivise and promote a green business model.

The four basic requirements factors are:

- Access to capital and investment
- High levels of R&D and investment in new technology (new, re-fitted, state of the art)
- Skilled workforce
- Existing/developing clusters of knowledge and transferable technology (including proprietary rights).

Whilst the two driving factors are:

- Favourable market environment in terms of customers demand (providing a market for new products)
- Regulatory regime (providing certainty and incentives).

Finally, in addition to such driving factors what emerged in many case studies as a key critical element for a successful green business is the role of 'early movers' – the early development and involvement in innovative areas anticipating regulatory regime changes, and changes in customers demand

3.4 Basic requirements – supply side factors

Access to capital and investment

Ease of access to capital for investment, to rapidly accelerate the transfer of innovations to marketable products is important within a rapidly evolving global market. Companies need confidence that they can access competitive funds to make the most of existing and future opportunities. The recent expansion in venture capital investment in clean technologies highlights the importance of easy access to capital for the development of low-carbon technologies.

Furthermore, it is important to ensure that there is no equity gap in clean tech investment – i.e., that there is not a range of deal sizes where funding would not be provided by the market as they are out of reach of private individuals and too small to be considered by institutional investors. There are estimates that suggest a fall-off in informal investment at around £250k whilst venture capitalists are unwilling to invest at a level below around £2 million. However, analysis conducted by Library House shows that for the clean tech sector in Europe there seems to be no evidence of an equity gap. This is in part due to the role played by public sector organisations, which are very active in the £200-400k range – the Carbon Trust in the UK being the primary example. [32]

The UK has a well developed investment community, and it is one of the preferred locations for Foreign Direct Investment – particularly from Japan and the US – with a clear leading position with regard to business and financial services and software products. The UK is also ahead of its major European competitors in attracting venture capital in Clean Tech companies (see paper 1).

[32] See "Cleantech goes mainstream", Library House, 2007

High levels of R&D and investment in new technology

Technological innovation is critical to increase the productivity of the economy, both in terms of the production of new and different goods using the most sophisticated production processes, but also in terms of the ability to adopt existing technologies to enhance productivity, and to the exploit new markets that may be facilitated by any move to a low carbon resource efficient economy. A culture of innovation can be supportive in encouraging R&D, this does not have to be found exclusively within small firms, but large firms may have to work harder to encourage it.

Skilled workforce

Quality education and training is crucial to create a pool of well-educated workers who are able to adapt rapidly to changing environment and to transfer skills across different sectors and activities. Research institutions and the academic establishment play a key role in developing this adaptable workforce.

Existing/developing clusters of knowledge and transferable technology

Clusters often occur when knowledge is easily and swiftly transferable between manufacturers, suppliers, research and educational institutions. This can occur when they are based in close proximity to combine expertise, innovation and technology into a strong industry. It can enable technological leaps and transfers to be made, within and across industries and sectors. Proprietary rights need to be protected by robust and enforceable patent and intellectual property legislation to protect these market constituents. The UK performance in this area is moderate, in terms of clusters and ease of technology transfer, though analysis of patterns of foreign investment in the UK shows that South East England has over time developed as the preferred location for investment in financial services and software products.

3.5 Drivers of green business

The recent expansion in the green or clean tech industry and the success of companies operating in the sector has been driven by change in the market environment - both in terms of the regulatory regime (providing certainty and incentives) and in terms of customers demand (providing a market for new products). In fact, a study on recent developments in the clean technology market in the United States highlighted changes in public policy and public (including investors) awareness as the two key reasons behind the current clean tech boom.[33] Highly competitive markets (and therefore the need to provide new and differentiated products at lower prices) and the rise in energy prices have also contributed to shift the focus towards ‘greener’ (and more efficient) products and processes. However, it is clear that clean tech products have particularly benefited from a shift in consumer preferences towards greener and cleaner products and a simultaneous trend in actual and expected public policy intervention in environmental regulation.

3.5.1 Public awareness

Global environmental pressures and public awareness

The public has clearly grown increasingly aware of environmental issues, judging by public opinion polls showing rising public concern about global warming and energy security. Over the past few years public awareness of, and concern about, global climate change has risen considerably.

Private companies followed closely such change in public attitudes. For example, in the United States on in January 2007 10 major US companies in collaboration with four environmental groups called for swift action on global climate change – the United States

[33] Clean Tech venture capital: how public policy has stimulated private investment, E2 and Clean Tech Venture Network, 2007

Climate Action Partnership (USCAP) called for federal action on carbon regulations.[34] In addition, the proliferation of organisations focusing on going 'carbon neutral' is an indicator that concerns over climate change have firmly taken root in the public at large.

Furthermore, companies around the world are realising that reducing their environmental footprints can also provide benefits for business. A 2006 survey of 150 companies in the US, UK, France, and Germany by AMR Research found that the top environmental concern among the executives in the survey was 'Energy and Emissions Reductions.' As companies are increasingly scrutinized on their stewardship of the environment, corporate social responsibility has become a key component of almost every company's business strategy – and a means of gaining a competitive advantage over others. Even without government regulations, energy use and greenhouse gas emissions have apparently risen to the top of the list of targeted activities.

Capital markets acceptance

This has also led to an increase in capital markets acceptance. Investors, understanding the level of public interest in climate change issues have started to invest in industries that reduce human impacts on the environment. The clean tech market originally consisted mostly of specialist investment firms and people with a strong environmental focus. However, with many of the world's major public and private equity investment entities committing capital to clean tech – and several market indexes in existence that focus exclusively on clean tech companies – the industry can now be considered mainstream.

Nevertheless, the shift in pubic awareness and desire for more action both at corporate and government levels has not completely changed consumer preferences. Business leaders still believe that the majority of customers will not pay a premium purely for a greener product. Customers want 'green' as an added benefit, whilst they will still consider price, convenience, and performance before green attributes. Being green is a benefit which is growing in importance but a majority of customers is still not likely to compromise.[35] There is, however, a large enough (and growing) segment of the population that is prioritising green factors and therefore provide an attractive market for a number of companies. Such niche markets are growing and therefore the opportunities for business are still considerable since these niche green markets will account for several billions in annual revenue. Companies therefore will try to capture market share in the market for expanding niche 'green' products by promoting the different qualities of their products – as part of their business strategy they will aim to differentiate themselves through 'green branding'. In fact, to be successfully green, businesses need to not only implement cleaner business practices and reduce their carbon footprint, but also to develop better communications with their customers. This will provide the opportunity to establish their brand and create large market demand for green products.

3.5.2 Public policy

Different surveys have shown that government policies have had an impact on the recent development and success of the green and clean tech sector, and could have an even stronger effect in the future. A survey conducted for the Clean Tech Network Group shows that in the US investors tend to keep a close eye on policies that might impact the industries in which they invest, and many these days have recognised the very strong likelihood that significant climate change legislation – for example, a mandatory national carbon cap-and-trade system – will be passed within a few years, significantly expanding the markets for cleaner technologies. State and local initiatives also provide assurances that a long-term market will exist. California's Low Carbon Fuel Standard, for example, is expected to triple the size of the state's renewable fuels market, which has made the state a magnet for biofuels investments ($390 million of the $850 million invested in biofuels from 2005 to 2006 went to California).

[34] United States Climate Action Partnership. (2007). http://www.us-cap.org
[35] "Clean Tech matters", Ernst and Young, 2008

In broad terms, current policies affecting 'green business' can be grouped into four categories:

- Those that ensure market demand for 'green' or clean tech products or services.
- Those that create markets for environmentally-friendly attributes or credits.
- Those that provide extra financial backing (directly or indirectly) to 'green' or clean tech companies – through funding or subsidizing clean tech products or services, or through tax/tariff policies.
- Those that provide business development assistance or other indirect assistance to 'green' or clean tech companies.[36]

Ensuring market demand for clean tech products or services

Governments can directly stimulate market demand by leveraging their own buying power through procurement policies. By making large clean tech purchases, governments not only increase the market size for such products (which helps bring their prices down through economies of scale), they also set a strong example for ordinary consumers that clean tech purchases are good for society.

In the German state of Schleswig-Holstein, stringent targets were set for 2010, reduction in CO2 levels (15%), increased in share of renewables in end energy consumption (25%), increased share of electricity from renewable in electricity consumption (50%), increased share of electricity from CHP in electricity consumption (30%), all against 1990 levels. As a result of early adoption of State environmental regulations, designed to compliment federal government policies, and active engagement and communication with communities (to communicate message and drive up acceptance for measures), Schleswig-Holstein's wind industry has grown considerably to become fundamentally important to its economy. It employs currently an estimated 5,000 people, a figure likely to double by 2010 and it generated in 2004 income from Renewable Energy Feed-In-Law of around €350 million.

Governments can also create demand indirectly by requiring a certain amount of energy to be produced from a particular technology, thus incentivising investment in its production. The most common types of indirect policies in this category are renewable fuels or electricity standards or obligation. Legislation of this type have been in place in many different countries – from the Renewables Obligation in the UK to portfolio standards in the US where at least 23 different states and the District of Columbia have some form of RES requiring that a certain amount of its electricity usage come from renewable sources (although there are several different definitions of 'renewable' and many different energy level requirements).

Similarly, government policies of support to renewable and particularly wind technologies have produced substantial benefit to the clean tech industry in Denmark. The wind manufacturing industry employs 21,000 in Denmark alone, have a combined turnover of almost 3 billion Euro and Danish wind turbine manufacturers hold a world market share of approx. 40% (see below for more details on the Danish wind case).

Creating markets for environmentally-friendly attributes or credits

One of the most commonly cited proposals for dealing with climate change is establishing a carbon price through an emissions 'cap-and-trade' system, whereby greenhouse gas (or carbon) emissions would be 'capped' at a given level for different companies, and those who exceed their allocated limit are required to buy credits to cover their surplus from

[36] In this paper we use the term clean tech company as a alternative for 'green business'., as the vast literature in the area tend to identify green business as clean tech companies. For a discussion on the definition of green business see paper 1 above.

those who emit less than their limit. The world's largest carbon emission cap-and-trade system is the European Emission Trading Scheme which began operation in 2005.

In the US, a small number of states and other independent actors have banded together to create emissions markets – placing an actual value on greenhouse gas emissions for the first time in the U.S. In 2005, the governors of seven states from the Northeast and Mid-Atlantic regions (Connecticut, Delaware, Maine, New Hampshire, New Jersey, New York, and Vermont) established the Regional Greenhouse Gas Initiative (RGGI), the country's first mandatory cap and- trade program, thus creating a carbon marketplace designed to reduce the region's greenhouse gas emissions by 10 percent by 2019. A Federal Reserve Bank of Boston analysis of the effects of RGGI concluded that the program, when coupled with an energy efficiency programme, will likely have a "*modest positive impact on gross regional product, personal income, and employment*." In particular, RGGI is likely to accelerate growth for some clean tech companies in the region. At the same time though, a study by the Energy Information Administration (EIA) put the cost of a cap and trade system at federal level to regulate greenhouse gas emissions at $292 over the 2009-2030 time period at $232 billion (0.10 per cent of GDP).[37]

Providing extra financial backing (directly or indirectly) to clean tech companies

These polices take the form of subsidies and incentives or tax credits for clean tech products, or taxes on non-clean tech products. These programs are typically financed by taxes and often result in increase in energy prices. The programs have, however, also demonstrated an ability to generate a positive return, which could ultimately lower customers' bills. A study by the RAND Corporation on California's energy efficiency program showed the program resulted in an increase in the state's economy of $875 to $1,300 per capita between 1977 and 2000, a 40 percent decrease in air pollution emissions from stationary sources and a reduced energy burden on low-income households.[38]

The most effective subsidies are stable
The renewable energy Production Tax Credit (PTC) is equally important to the success of the wind energy industry, which faces both economic and technical hurdles in competing with traditional fossil power sources. But unlike the VEETC and the ethanol import tariff, which have remained in place for many years, the PTC has exhibited highly variable dynamics, lapsing and being renewed approximately every two years – to the consternation of investors and companies, who find themselves unable to plan ahead in such an uncertain environment. As a result of this policy uncertainty, the wind industry has experienced a dramatic boom-bust cycle.

Taxes and tariffs have also had considerable implications for the level of investment in clean technology products. There is strong industry consensus that the biofuels boom of 2005-2006 in the US was aided considerably by the federal Volumetric Ethanol Excise Tax Credit (VEETC).

Other indirect ways to provide financial backing is through public investment or loan guarantees. We mentioned previously about the important role of public investment in supporting early stage development of clean tech products, particularly in stimulating the growth of innovative young companies.[39] Analysis from Library House based on CleanTech Network data suggests that one of reasons for the success of US and UK in stimulating venture capital investment in clean tech is the participation of public investment in supporting early stage development of small and medium companies. In general, there appears to be a positive relationship between the level of public sector engagement with early stage cleantech companies and the number of these which ultimately receive venture capital backing. This therefore suggests that public sector engagement with early stage

[37] See "Energy Market and Economic Impacts of a Proposal to Reduce Greenhouse Gas Intensity with a Cap and Trade System", EIA, DOE, 2007, available at: http://www.eia.doe.gov/oiaf/servicerpt/bllmss/index.html
[38] See "The Public Benefit of California's Investments in Energy Efficiency", RAND, 2000
[39] See paper 1, section 1.5.2 above.

cleantech companies, in the form of grants or equity investments, is very important in stimulating cleantech venture capital activity.[40]

The Department of Energy in the US is currently setting up a loan guarantee program to help promising ideas get the financing they need. The DOE is supporting an array of advanced technologies with a focus by the Office of Energy Efficiency and Renewable Energy (EERE) on commercialisation of solar PV by 2015 and an increase in use and production of cellulosic ethanol and other biofuels. Programs include the Advanced Energy Initiative and the "20 in 10" plan.

Providing business development assistance or other indirect assistance to clean tech companies

The public sector has a variety of other tools at its disposal to boost the clean tech industry, for example:

Public education investment – One of the major reasons commonly cited for the emergence of California's Silicon Valley as a major hub of the Clean Tech industry is the presence there of two major universities – University of California of Berkeley and Stanford – with world-class scientific research programmes and top business schools. These two institutions graduate a pool of first-class technical researchers and business-savvy students, many of whom become entrepreneurs.

Clean tech incubators and business assistance – Incubators help young companies develop the business skills and acumen critical to becoming commercially successful. Typical incubators enable their companies to share office space, basic business services, technical support, and equipment in order to save costs. They also generally offer management advice, technical assistance, networking opportunities, consulting services, and assistance obtaining financing. Incubators can be targeted to specific industries, like clean technologies, or open to a broader range of companies, but whatever their form, they are likely to improve the survival rate of new start-ups and speed the product development and commercialisation process.

Public leadership – Over the past few years, a variety of public and private citizens have all used their public prominence to raise awareness about global climate change. By voicing their backing for 'green business' and clean tech industry development, public leaders can continue to raise awareness on the subject, and send a message to companies investing in clean technologies that they will receive strong public support in that area.

3.6 The role of early development and involvement in innovative areas

In many examples from our case studies, successful green business moved early to develop new clean or low carbon solutions to differentiate themselves from competitors (through branding but also by promoting a new 'quality' in their product) or to gain experience and market position ahead of an expected change in regulation and/or consumer preferences. In fact, the anticipation of change and the successful planning to benefit from it are critical for companies and policymakers. Early development of a new product can result in being first to market with new products and services, which if exploited successfully can lead to successful comparative advantage. On the other hand, second mover advantage (or as usually referred 'fast follower'), where market movements are observed and lessons are swiftly learnt from first movers, can offer market potential with reduced efforts in terms of research and development.

In many instances, and particular for first movers (and large) companies the movement to low carbon technologies and products derives as much from internal cultural change (to a

[40] See "Cleantech goes Mainstream", Library House, 2007

certain extent driven by changes in external consumers environment) and a business strategy that promotes innovation to keep market share and remain on top, as from direct government intervention.

Support from government is important, however, even when it is business that starts voluntarily to introduce green products or targets. In fact, expectation of government intervention is as strong an incentive as it is direct government intervention. As the case studies showed, in many different cases the comparative advantage was gained by moving into a new area in response to expectation of regulation and also in expectation of a change in consumers' preferences and demand.

For example, in one of the case studies examined, a leading global chemical company, promoted early involvement in innovative areas including emissions trading, to gain valuable insight and experience in order to achieve leadership status in the market for incorporating green business modelling in its activities but also to generate cash flow to defray the cost of emissions reductions measures.

Furthermore, as observed by interviews with industry, one of the motivations leading a company to anticipate government regulation is not only to avoid future costs, but also to be in a position to shape future legislation and regulation, and therefore lock in any advantages gained.

The Danish wind sector is a frequently cited example of the first mover advantage and a case study for providing policy and financial support for early stage technology in the green business sector. The case study is undoubtedly an example of how innovation could be supported before the green sector becoming the large global industry it is now evolving into. We give here a short overview of why many of the measures taken to support the Danish wind, and indeed other green technologies in early stages internationally, are not considered applicable in today's green business market for the UK.

Specifically, the Danish wind sector (and similarly the German and Japanese solar, South African coal gasification to name some other examples) was developed at a time when demand for green products in general and wind turbines in particular was not an international market. The majority of Danish wind turbines were used in Denmark. A very generous and stable long term support mechanism, as well as laws and close stakeholder involvement through guilds which reduced planning risk, meant that the Danish wind market exhibited stable and cumulative growth over a long period of time. This was in contrast with wind subsidies put in place in California and the UK (under the Non Fossil Fuel Obligation) which proved much more erratic, and resulted in the fledgling wind turbine industries in those countries not being able to survive the downturn in demand caused by market factors outside their control.

So while the wind industry has developed into one of significant benefit to the Danish economy, and the policies followed at the time by the Danish (as well as for solar in Germany and Japan), were clearly of long term benefit, their success now would be much less certain. The data presented in Paper 1 showing the strong growth of clean technology venture capital investment in the US against the much slower growth in European investment provides the primary data point for our conclusion that regulatory and subsidy support for green businesses are not the only or even the key component. The situation today in clean technology markets could not be more different to the early stage development of those green technologies in Denmark and elsewhere. The US boom in clean technology is primarily not driven by policy in the US, but rather by expectations that demand for 'green' and clean tech products and services in the US and globally will continue to grow.

3.7 Conclusion

The analysis of the case studies of successful green business showed that there are a few pre-conditions that need to be in place for the development of a successful low-carbon or clean tech sector.

Critical to the successful development if green business are a set of supportive policies and regulation, and a favourable demand environment in the shape of highly aware consumers which are willing to include low-carbon or green as important quality criteria in their products purchase assessments. The UK government has been one of the leading countries on the issues of climate change and it is likely to be the first country to institutionalise carbon emissions targets into law (through the Climate Change Bill). The UK government has also been active in the support of early stage clean technologies particularly through the action such as the Carbon Trust.

It is also important to note the role that expectations plays in creating a favourable market environment. Both case studies and discussion with industry highlighted the importance of anticipating regulatory changes or consumer preferences shifts for the success of green business. Many companies (and to a certain extent regional government) have actively promoted green or low-carbon products and services in anticipation of future regulation both to avoid the burden of later regulations and to gain an advantage in the market through reputation and experience. The effectiveness and the certainty of the regulatory regime are still important as companies would move and invest based on expectations only if they do not expect surprises and regulation has proven consistent – based on a stable regulatory framework and limited and foreseeable regulatory intervention (to avoid shocking the market).

However, the key necessary *success factors* seem to lay on the supply side, in creating the right conditions for the investment and development of low carbon, resource efficient products. Supply side factors such as access to capital, a skilled workforce and a strong innovative and technological base (often in the form a high-tech cluster) are in fact key requirements for a green or clean tech business model. As demonstrated in section 1 and 2, the UK has been very strong in attracting investment in high tech sector and services and therefore it appears to be at the forefront of the clean tech investment in Europe.

There is also evidence to suggest that while demand and supply side factors act together and reinforce each other to create specific successful green businesses such as the Danish wind sector, in future the twin effects of global competition and adoption of green products and services beyond first mover markets today may make the support of supply side factors dominant over the demand side. The recent emergence and dominance of the US clean technology sector in taken as evidence of this future trend.

Finally, the key supply side success factors are not specific to the clean tech or green sector; they are more broadly generic factors which can be applied to all successful businesses though they manifest themselves in different ways in relation to green business strategies. This suggests that policy makers should consider how to best align the demand factors, which can be influenced through regulation, and supply side factors, which can be influenced through business support policies, in order to encourage businesses to adopt such factors in implementing their green business strategies.

For investors in green business, both corporate and venture capitalist, the search for higher returns and optimum allocation of capital warrants an assessment of not just demand side drivers, but equally supply side drivers which we describe as having many of the attributes of non-green business innovation and entrepreneurialism. The importance of an entrepreneurial and innovative business culture undoubtedly enables development of supply side solutions which in the long run are likely to be more effective than regulation and subsidy. Although these demand side drivers can be a necessary precursor in early stages of new industries, such as green business, once widescale adoption and mass-market forces become engaged, their effectiveness and impact wanes.

3.8 Annex 1 – Case studies

Schleswig-Holstein

Schleswig-Holstein is the Northernmost Bundesland (State) in Germany, with coastlines on both the North and Baltic seas. There has been concern about climate change at regional government level, crystallised by €50 million spent on coastal protection over 10 year period. As a result environmental policy legislation has gained a higher prominence than in other parts of Germany. Stringent targets were set for 2010 - reduction in CO2 levels (15%), increased in share of renewables in end energy consumption (25%), increased share of electricity from renewable in electricity consumption (50%), increased share of electricity from CHP in electricity consumption (30%), all against 1990 levels.

Innovative schemes allowed locals to invest in wind farms, thus ensuring high levels of local acceptance. Schleswig-Holstein was the first German State (2001) to have its biomass programme co-financed by the EU as part of its agricultural subsidies. Schleswig-Holstein has pioneered energy efficiency standards in new buildings, and implemented an Energy Saving Decree, 2 years before it was introduced on the Federal level in 2003. This decree requires a minimum standard of energy efficiency in order to receive grants for construction of new housing. Sustainable criteria for new industrial parks have been introduced.

As a result Schleswig Holstein now sources more than 1,800MW of its power from wind (other renewable technologies developed are biomass and solar PV). The wind industry employs an estimated 5,000 people, a figure forecast to double by 2010. In 2004, Schleswig-Holstein's wind energy sector generated income from Renewable Energy Feed-In-Law of around €350 million

Activities

- Early adoption of State environmental regulations, designed to compliment federal government policies
- Active engagement and communication with communities to communicate message and drive up acceptance for measures
- Inclusive approach, allowing local community to invest in process and feel included
- Set and communicated challenging goals, at an early stage
- Recognised opportunity to get financial support from EU

US Cleantech

Cleantech companies are often start-up companies funded with venture capital or private equity (see paper "Definition and characteristics of green business"). In 2007 investments in clean technology surged to almost US$3 billion. As global economies become low carbon and resource efficient, the ability to identify, finance, and grow promising cleantech businesses via private equity and VENTURE CAPITAL investment is likely to become an increasingly important comparative advantage. The US demonstrates an absolute lead both in the number of cleantech firms receiving funding, and the cumulative amount invested, both total more than the rest of the world combined. Clusters exist in the US, in the Bay Area, Southern California, New England and New York.

Activities

- A supportive policy and regulatory regime in US as well as the size, dynamism, and relative stability of US economy

- Clusters - dominance of the Bay Area (California) suggests that skills developed in the boom years of the IT sector have been leveraged into the cleantech sector, in particular this includes a base of lawyers, bankers, accountants, and consultants with deep experience of helping an early stage company grow on the road to commercialization

- Access to capital in the form of venture and private equity funds

- Highly educated and creative workforce

Danish wind sector

The 1970's oil crisis stimulated Denmark to diversify power generation away from its oil based reliance. The state invested heavily to aid this evolution. Denmark's wind industry is a first mover, and the sector continues to achieve impressive results, it ranks among the top 5 markets in the world today. 3,100 MW was installed by the end 2005 and in 2004 – wind power accounted for 20% Danish electricity consumption.

The Danish industry also leads a new challenging market, offshore wind. By 2003 global offshore installations had reached 530 MW, 492 MW were of Danish origin. The offshore market involves many different sectors from consulting engineers to companies with special vessels designed to transport, install and maintain the turbines. Danish companies have developed skills that give them a leading comparative edge.

The Danish wind industry employs over 20,000 and Danish wind turbine manufacturers hold a world market share of over 30% (with a combined turnover of almost 3 billion Euro)

Activities

- Supportive government regime, the Danish Government instituted a support programme for the erection of wind turbines in Denmark during the 1980's

- Stems from an unrivalled cluster of knowledge where manufacturers, suppliers, research and educational institutions are based in close proximity to combine expertise, innovation and technology into a strong industry

- Danish research institutions established the Danish Research Consortium for Wind Energy in 2002, comprising approx. 150 researchers working with meteorology, fatigue loads, aero- and structural dynamics, grid interaction etc

- Diversified early into associated sector of offshore wind

Lafarge

The cement industry, an energy intensive industry, it is subject to the EU ETS emissions targets. Lafarge has embarked on an investment programme to build new plants and upgrade existing ones, with a strong focus on improving energy efficiency (energy accounts for approximately 30% of cement costs). It is also actively sourcing low carbon raw materials, and implementing innovative process changes to re-use by-products as additions to traditional cement. This includes using blast furnace slag from the steel industry and fly ash from coal-fired power stations which have cement like properties, and research into replacing limestone itself in cement process. Lafarge is actively promoting sustainable architecture solutions and is developing higher performance cement which will result in the reduced consumption of materials and a reduced carbon footprint. Lafarge is investing in offsets via UNFCCC's Clean Development Mechanism (CDM), and it currently sources 9.8% of its energy from renewable sources and alternative fuels including biomass and waste (biomass is used to recycle waste products in to fuel).

As a result of its efficiency efforts, applied across all business areas from emissions trading to product development and innovation, Lafarge has achieved 16% reduction in CO_2 per unit of production since 1990. Lafarge is also using its influence to drive improvements across the cement sector.

Activities

- Set and communicated challenging goals across company, targeting a 20% reduction in CO_2 per unit of production by 2010

- Research and development in new product technology

- Technology change reducing CO_2 usage in product manufacture

- Anticipating global roll out of EU regulatory regime

DuPont

DuPont, a leading chemical company with global reach, has invested to deliver process changes, with a $50m investment to retrofit facilities across 3 continents to reduce NO_2 emissions, and re-modelling of costs to maintain flat energy usage. This has led to 55% reduction in global GHG emissions. Investment in energy efficiency allowed the company to hold energy use flat between 1990 and 2000 while increasing production 35% and saving the company $2 billion. It has also focused on developing environmentally beneficial products that enable improvements elsewhere in the supply chain, such as Tyvek©, a material providing buildings with greater insulation, and the provision of electronics for hybrid vehicles and lightweight auto materials.

DuPont is sourcing 10% of energy from renewable sources, and purchasing 170m kwh of Renewable Energy Certificates annually. DuPont also undertakes emissions trading to generate cash flow to defray the cost of reductions. It has helped to start up several external emissions trading programmes, including the Chicago Climate Exchange and the UK Emissions Trading Scheme.

Activities

- Education to ingrain environmental stewardship in to the organization by setting and communicating challenging goals across company

- High levels of research and development in new products

- Early involvement in innovative areas including emissions trading, gaining valuable insight and experience

BT

BT is undertaking a global business initiative to reduce CO_2 emissions to 80% below 1996 levels. Some of the drivers for such initiative include its feeling of vulnerability to rising energy prices, security of supply issues, and its own forecast increase in demand because of new network equipment roll out.

BT is taking action up and down its supply chain to encourage reduction in energy use by suppliers and customers, for example it's developing a Carbon Audit service to help business customers understand the carbon footprint of their ICT systems and use technology to reduce their overall emissions. In the 2007 financial year, BT spent over £6.8 billion on procurement. The company has tightened the environmental criteria in its procurement principles. These cover the energy consumption and environmental impacts of products and services, from manufacture to usage and disposal which will increasingly become a contract adjudication criterion.

Other actions include negotiating the worlds biggest green energy contract in 2004 (renewed in 2007); the use of video conferencing by staff, cutting over 800,000 face to face meetings (leading to savings in the order of £238m – £135m in travel and £103m in time); switching to air rather than refrigeration cooling, and employing design changes in data centres to enable more natural cooling, is helping cut energy, and use of gases like HCFCs and HFCs. This exercise helped identifying 23GWh of power savings in data centres. As a result of these initiatives BT topped the Dow Jones Sustainability Index for six successive years among telecommunications companies

Activities

- A change in culture with the introduction of its climate change strategy, which has four elements, setting out how BT will reduce its carbon footprint; influence its customers; influence its suppliers; and engage its employees. Internal 'carbon busters' recruited, to champion behaviour change

- Dialogue with customers and suppliers to broaden influence

- High levels of research and development in innovative processes aimed at reducing CO_2 usage in product manufacture and operations

Comverge

Comverge is a clean energy company providing innovative solutions that significantly reduce peak electricity costs and increase grid reliability. Its purpose is to help lead the evolution of the energy industry with environmentally friendly solutions. Big utilities pay Comverge to help them reduce power usage, which therefore saves them having to build extra capacity that would be used only occasionally. Network participants typically get paid for their conservation efforts by the demand-response companies like Comverge.

Comverge has developed Virtual Peaking Capacity™ programs, load management and control systems, and real-time energy data collection and management. Demand response, advanced metering, and grid management solutions are all designed to assist utilities and end consumers in utilizing energy "smarter" and more efficiently by linking together big electricity users -- industrial companies, hospitals, supermarkets, even private homes -- in a high-tech network that automatically reduces participants' electricity usage when the power grid is strained. The energy management products collect, store, process, present, and deliver energy analysis to customers, encouraging behavioural change.

Activities

- Comverge stresses creativity and innovation in the workplace, encouraging "out-of-the-box" thinking and new ideas through a culture of innovation.

- Investment in state of the art technology

- Cascade industrial solutions into residential market

Coca – Cola Amatil

It's a production plant based in Brisbane, Australia. Water shortages and drought are becoming fact of life in Queensland. The water saving effort at the site is based on the principles of: Eliminate, Reduce, and Recycle. The approach has involved investment in refitting machinery to capture and reuse water, the use of smaller nozzles that cut water used in the bottling process, the use of a nano filtration plant for product water. Across the site grey water is recycled for use in the toilets, truck washing, and on the gardens. Coca Cola reduced water consumption by 20% from 2004 to 2006, whilst plant production increased by 11% during the same period, resulting in savings of approximately 46 million litres per year

Activities

- Cultural change, taking a more proactive approach to managing water resource to mitigate risk, where water saving is considered a necessity, not a luxury innovation

- High levels of research and development in new products and also investment in refitted technology

- Assessment made of complete operations process to identify opportunities to cut usage

Ceres Power

Ceres Power has developed world's first commercial metal-supported solid oxide fuel cell operating at an intermediate temperature – it has thus designed a compact, wall-mountable Combined Heat and Power unit capable of generating electricity and all of the hot water and central heating required for a typical UK home, without the need for a separate boiler. It works with a range of fuels, including LPG, natural gas, methanol, hydrogen & vehicle fuels, making it ideal for mass market uses. The technology is based on over ten years' research at Imperial College, London. Ceres Power was founded in 2001, and enjoyed a successful IPO in 2004 on London's AIM, valued at £66m.

Ceres Power is partnering with British Gas and BOC in a development programme to accelerate taking the product to market. Recent investment by British Gas values company at £200m (£20m for 9.9% of company). Ceres Power benefited from early stage investment from the Imperial College technology transfer company, Imperial Innovations, which also runs one of the four Carbon Trust incubator schemes.

Activities

- Promotion of innovation, and investment in long cycle product development

- Access to capital in the form of floatation and equity funds

4. Economic benefit of supporting development of green business

4.1 Executive summary

In order to identify how the development of comparative advantage in green business might impact the UK economy, Oxford Economics have undertaken analysis using their proprietary general equilibrium Oxford Energy Industry Model. Four simulations of how developing green business in sectors where the UK currently has comparative advantage would impact on the wider UK economy have been developed. The fours simulations are:

1. On the supply side, a technology innovation yields both a greener and larger economy. A simulation is made of this occurring in the manufacturing sector;

2. On the supply side, a policy results in a greener but smaller economy. A simulation is made of this occurring in the renewable energy sector;

3. On the demand side, consumer preference creates the opportunity for a UK industry to develop a non-price comparative advantage related to greener production. A simulation is made of this occurring in the chemical sector; and

4. On the demand side, policy creates a new market in an area where the UK already has a comparative advantage. A simulation is made of this occurring in the carbon trading markets.

We have used conservative input assumptions in order to assess the impact on the wider UK economy in a highly controlled and constrained methodology. Even under these conditions, we find that our simulations indicate that while some developments could boost UK Gross Domestic Product (GDP) others could have a negative impact on GDP. Furthermore, the impacts within different sectors can vary significantly, and spillovers from one sector to another can be appreciable, particularly for enabling technologies. Further work might be required at a sectoral level to understand the strength of the various success factors and the relative relevance of policies for particular sectors.

In reality, input assumptions may turn out to be much stronger, and the transmission modes likely to be less constrained, occurring in series or sequence. We recommend that the preliminary analysis undertaken here be extended using all four identified transmission modes in combination across many or all sectors of the economy, to assess if the aggregate impact on economic growth may be expected to materialise. We also note that traditional economic analysis of the type we have undertaken might not reflect the nature of a significant discontinuity such as climate change. It may be helpful to consider complementary approaches such as analysis of how the UK created comparative advantage from other discontinuities such as the development and expansion of the internet.

4.2 Introduction

This section provides some illustrative examples of how applying the principles of green business to sectors in which the UK currently enjoys comparative advantage impacts the wider economy. Whilst we have chosen sectors of the UK economy where the UK already has comparative advantage, this modelling exercise is aimed at illustrating the effects at work rather than highlighting sectors for particular attention. In addition, the quantitative results of the modelling, though relevant, have to be seen as an illustration of the potential effects at work rather than an actual forecast. In this context, it is useful to differentiate between impacts driven by developments that alter the trade-off between the degree of 'greenness' in the production process (in terms of energy intensity and/or carbon intensity) and the productivity of the economy (supply side effects) and those driven by changes in consumer behaviour or consumer preferences (demand side effects). In practice though, there will often be an interaction between both these types of generic effect.

In the illustrative examples set out below we have sought to show how these types of impacts might be analysed in a number of sectors settings. First, there is what might be called the 'win-win' type of situation where innovation improves the trade-off between greenness and productivity. At the extremes this allows either more to be produced (a bigger economy) without adding to the environmental impacts, or the same level of production but with lower environmental impacts. In other words the innovation makes it possible to have both a larger economy and a more green economy. Improvement in manufacturing technology serves as an illustration of this type of impact (simulation 1).

Achieving green goals will often, however, involve economic loss compared with what would have been possible had the green goals or constraints not existed. This recognises the existence of a trade-off between changes in the degree of 'greenness', defined as lower energy and/or carbon intensity (and therefore the changing mix of the economy that results from seeking to meet low-carbon goals) and the level of productivity of the economy. Increasing 'greenness' might thus mean foregoing some production that would otherwise have been possible. For example, shifting to renewable sources of energy, with currently available technology, implies higher energy costs and so small losses in the overall GDP level over time (when compared with the business as usual case). This illustrates that while there may be sectors winners (the renewable industry in this case), there will also be small losses spread across the economy as a whole (simulation 2).

The economy may also become more green ('low carbon') if consumers shift their preferences towards greener products. Indeed, many businesses are already shifting their production towards green products in response to increased concern for the environment among consumers. If preferences alone shift, even in the absence of a price signal, then the economy could become greener even with the existing technology stock. Changing preferences, if perceived to be permanent, are also likely to drive effort by producers to deliver greener products. In turn these efforts may result in win-win innovations or make solutions to the greenness versus productivity trade off viable that were unavailable before the change in preferences. The development of a non-price competitive advantage related to the perceived greenness of a particular product or service (in this case within the chemical sector) shows how this type of effect might impact on the economy (simulation 3).

Carbon trading is in its infancy but is expected to form a key plank in the policy toolset towards addressing climate change. While the impact of carbon trading will be widespread across the economy, the London's comparative advantage in trading of financial instruments suggests that the UK is well positioned to capture a significant share of global carbon market trading. This activity will contribute to the overall level of output in the UK and is another example of an offset to the potentially negative impacts on GDP levels from the process of greening the UK economy (simulation 4).

The simulations in this section are achieved by using the Oxford Energy Industry Model to illustrate the economic interactions that follow from the expansion of a particular set of 'green' sectors. These simulations have been undertaken in a way that, while the policy mechanisms used to stimulate the sector are not identified, the investment and other costs of exploiting green potential are recognised, in order to ensure that, as in the real world, there are no free (i.e. costless) benefits accrued.

Finally, the simulations included in this section apply to sectors where the UK enjoys comparative advantage and therefore illustrate some of the benefits (and costs) that could accrue to such sectors. The figures obtained through such simulations should therefore be treated as purely illustrative and not as actual forecasts of how those sectors or the UK the economy will develop in the future.

Following a short introduction on the characteristics of the Oxford Energy Industry Model, we present the results for the four simulations built around the four different types of effects. For each simulation we first present the assumptions used in the modelling; second we consider the theory behind the effects at work; third we present the disaggregated results in terms of the various types of impacts; then we look at sectoral impact and the potential spillovers through the supply chain; and finally present the overall impact at the UK GDP level.

4.3 The Oxford Energy Industry Model

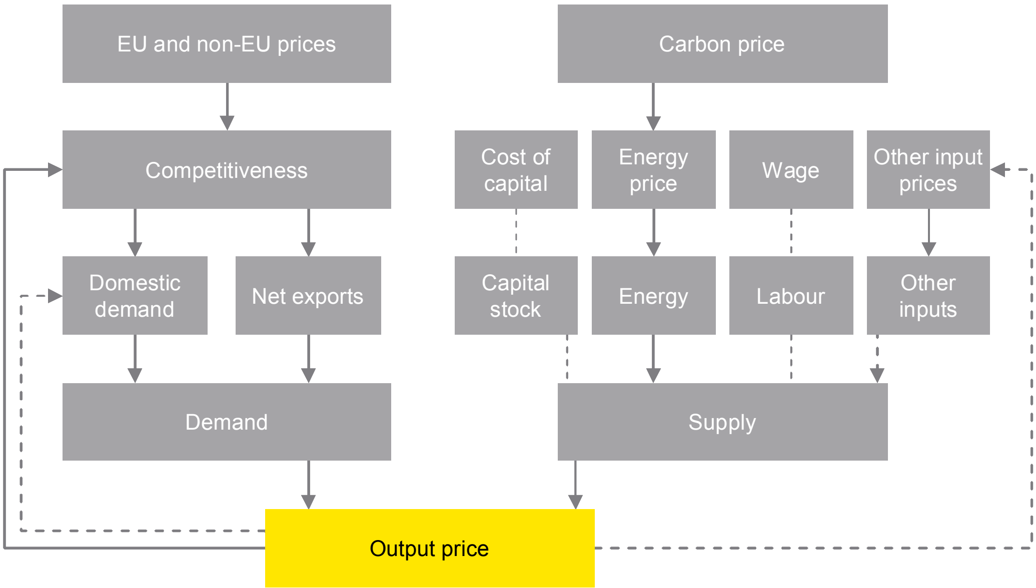
The Oxford Energy Industry Model (OEIM), which was developed as part of Oxford Economics contribution to "Meeting the Energy Challenge"[41] has been used to examine the impact at an economy-wide and sectoral level of an expansion in individual sectors where the UK develops comparative advantage through the 'greening' of the sector. The OEIM is essentially a large input-output model of the UK that was developed to analyse the sectoral impact of different policies aimed at reducing carbon emissions and therefore has a full set of demand – both final and intermediate – linkages as well as reflecting the impact of changing factor and output prices.

The OEIM embodies a four-factor production function for each of thirty industrial sectors in the UK, and has been adapted to show how demand for each factor of production (including energy), gross output and value added in each sector plus the household sector move around in equilibrium in response to changes such as the development of new 'greener' products or the development of 'greener' production processes. The OEIM also captures the way the economy shifts towards its new equilibrium.

Output in each sector is determined by labour, capital, energy and other raw materials and intermediate inputs to the production process. The factors of production are combined in a Cobb-Douglas production technology that exhibits constant returns to scale.[42] The long-run behaviour of each sector in the model is determined by the first-order profit maximising conditions derived from that sector's production technology. Each sector will choose the cost-minimising mix of all four factors of production for any given level of output, and will set the price of its output to maximise profits. Therefore, the quantity of each factor employed in each sector will be the result of the interaction between aggregate demand for that sector's goods or services and the vector of factor prices.

[41] "Meeting the Energy Challenge A White Paper on Energy", May 2007, Department of Trade and Industry
[42] The Cobb-Douglas production function is a representation of the relationship between inputs used in the production process and outputs. The form of this function assumes constant returns to scale. That is, if all inputs are increased by a given proportion then output will also increase by that proportion.

Figure 30: Oxford Energy Industry Model structure



The key drivers in the OEIM are:

- The energy intensity of production in each sector.
- The price elasticity of demand for energy in each sector.
- The slope of the demand curve for the output of each sector.
- The share of intermediate inputs in firms' costs.
- The share of imports within imports.
- The exposure of each sector to international competition.

Each sector in the model faces a downwards-sloping demand curve: demand falls if prices rise due to a supply shock. Demand is modelled as a function of domestic demand (both final customer demand and intermediate demand from other industrial sectors) and overseas demand. An important concept that affects the level of demand is the real exchange rate, which is determined for each sector, as a measure of competitiveness.

The external sector is exogenous; in the OEIM this is made up of foreign GDP and interest rates at the whole economy level, and output prices for each industrial sector, broken down into EU and non-EU regions. For the purposes of the OEIM, we assume that changes in those external variables are proportional to the changes in their UK counterparts, where the proportion reflects the relative level of competitive effort undertaken by countries outside the UK to match developments in the UK.

Outcomes for real variables such as output and employment in the model are determined by demand in the short run and by supply in the long run. The important long-run equilibrium conditions for this project are as follows:

- No sector could produce more than it does produce without losing profits.
- All sectors face the same constraints in terms of prices of capital, labour, energy and other intermediate inputs to the production process.

- The labour supply at the whole economy level is fixed in the long-run.

The features of the UK economy captured by this model imply that the whole-economy impact of a sector developing comparative advantage through green business is distributed highly unevenly across the industrial sectors.

While the properties of the OEIM are broadly consistent with those of an estimated, reduced-form equation relating energy consumption in the various industrial sectors to its key drivers over time, each of these assumptions is uncertain, and changing them would have a material effect on our estimates of the impact of reducing UK carbon emissions. It is therefore appropriate to be cautious about the magnitude of the effects that we identify.

4.4 Simulation 1: Increased manufacturing R&D yielding "greener" products

Assumptions

This simulation makes the following assumptions:

- Assume 12% (£1bn) increase in civil R&D spend, resulting in products that are "greener" to use – for example less polluting engines
- This raises manufacturing productivity and output.
- This then benefits supplying sectors (in the products' supplying chain) directly and through technological spillovers – it thus provides benefits in terms of higher productivity and 'greenness'.
- This boosts downstream sectors benefiting consumers & overall economy - though there may also be some second round offsetting effects on emissions if consumption of some goods increases.
- Increases overall output through higher productivity.

Effects at work

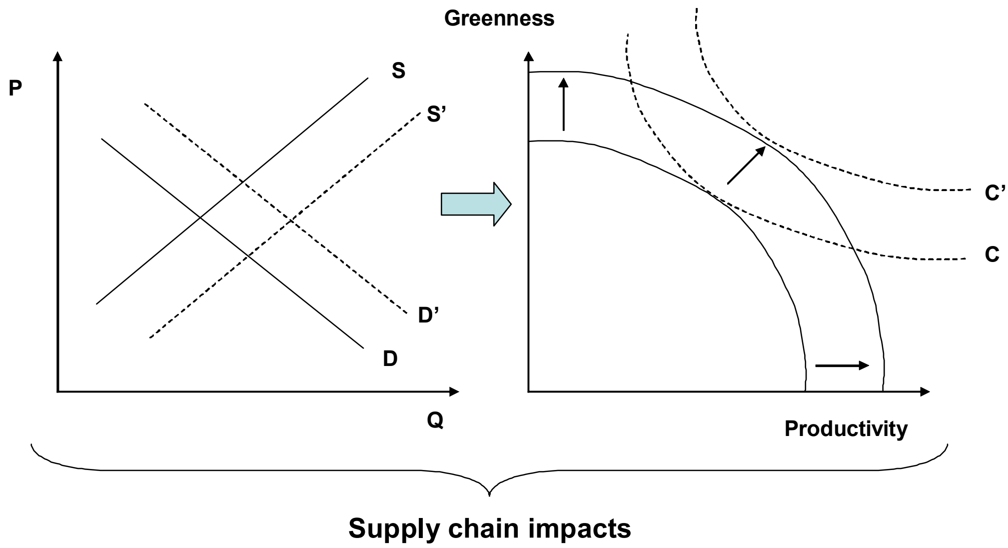
These effects are illustrated in Figure 31. The left-hand chart shows demand and supply of manufactured products. While the assumed R&D is undertaken because of the potential private returns (profits) offered, this R&D is likely to have spillovers into other sectors through increase in productivity, 'greenness', competitiveness and profitability.

The right-hand chart plots the frontier that shows the combinations of productivity and greenness, for example units of output per 1000 units of pollutants that are feasible. It assumes that there is a trade-off between productivity and greenness. That is, to increase the greenness of a product (or develop a new green production process) in the same environment (with the same technology stock) leads to lower productivity and vice-versa. An economy that is positioned on this frontier cannot improve the trade-off between productivity and greenness by simply adopting best practice.

However green R&D in manufacturing helps boost both productivity and greenness; thus shifting the whole production frontier of possible combinations of productivity and greenness outwards, with the sectors that are the focus of innovation, their supply chain and their customer sectors all benefiting. For example, vehicles powered by greener engines can be driven for more miles at a lower environmental cost. This lifts constraints on the use of vehicle transport, with downstream impacts on the productivity of a range of transport customer sectors and sectors which are heavily reliant on transport as input. It also drives expansion of the engine manufacturing sector compared with the business as usual baseline, which in turn has impacts through the supply chain for the industry.

However, not all impacts are positive. Where there is competition for scarce resources (for example in the labour market) some activities might be crowded out by the expansion of the manufacturing sector.

Figure 31: Impacts of increased R&D in manufacturing



Calibrating the effects

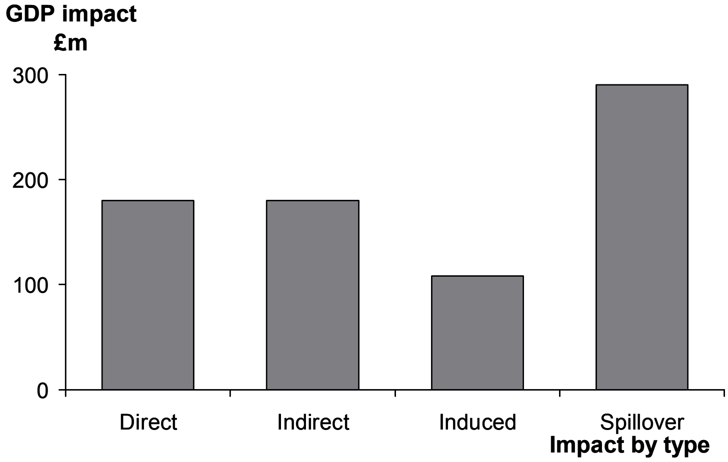
In calibrating the effects of an increase of £1bn in R&D spend in manufacturing in the UK (equivalent to an increase of 11.8% on the average level of spend for the period 2004-06), a number of impacts can be identified. These are the direct effect on the output of the manufacturing sector itself, the indirect effect through the industry's supply chain, the induced impacts of spending of the additional wages, salaries and profits earned in the manufacturing sector and in the supply chain and the impact of spillovers that affect both the supply chain and customer sectors.

The technological advances that come about as a result of R&D spending by one firm can be transferred to other firms and other sectors, in the form of 'spillover' effects. These 'external returns' to R&D can, in the long run, exceed the private returns. The firms and sectors that stand to benefit from another firm's R&D tend to be those that are 'close' to the source of the R&D – either technologically close or close in the sense of being linked in the supply chain.

We estimate that the private rate of return of R&D in the UK manufacturing sector is 18% - so the assumed £1bn spent on R&D generates a direct annual return of £180 million in terms of extra value added within the manufacturing sector. As shown in figure 32, in turn this results in a further increase in GDP of £180 million in indirect GDP as the additional demand for inputs from the manufacturing sector feeds through the sector's supply chain. The spending of the increased wages, salaries and profits that result from the higher level of activity in the manufacturing sector generates a further £108 million of additional GDP. However the largest impact flows from the "spillover" impacts from the original R&D activity, amounting to £290 million. A substantial portion of this spillover impact is represented by the productivity improvements that stem from the lower cost of manufactured inputs.

Figure 32: Impact on GDP from additional £1bn R&D spend in manufacturing

Source: Oxford Economics



Supply chain gains

Figure 33 ranks the sectors within the manufacturing supply chain according to the increase in demand that flows from increased output in the manufacturing sector. This illustrates that the benefits spread widely through the economy though with nearly two-thirds of the impact felt by suppliers within the manufacturing sector itself.

Figure 33: Beneficiaries in the supply chain

Source: ONS, Oxford Economics

Share of manufacturing procurement spend	%
Oil & gas extraction	5.0
Iron & steel	4.0
Motor vehicles	3.9
Agriculture	3.5
Plastic products	3.4
Metal forging, pressing etc	3.3
Other land transport	3.3
Printing & publishing	3.2
Organic chemicals	2.9
Non-ferrous metals	2.6
Paper & paperboard products	2.6
Plastics & synthetic resins etc	2.5
Electronic components	2.3
Pulp, paper & paperboard	2.3
Electrical equipment nec	2.2
Banking & finance	2.0
Electricity production &	1.8
Other metal products	1.7
Mechanical power equipment	1.7
Meat processing	1.6
Wood & wood products	1.5

Downstream benefits

The availability of greener manufactured products would allow more of the services derived from these products to be consumed for the same impact on the environment or would allow a lower environmental impact from a static level of their consumption. Given that the products of the manufacturing sector are important contributors to economic growth reducing some of the constraints on the expansion of availability of manufactured inputs enhances productivity and economic growth. This effect is captured in the spillover effects identified above.

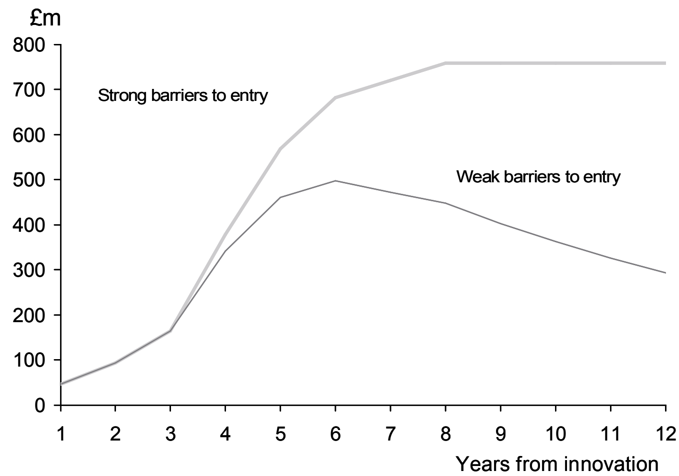
Overall impact on GDP

Figure 34 illustrates the profile of how the impact on GDP might be spread through time. For the purposes of the simulation it has been assumed that the impacts in the years immediately following the boost to R&D expenditure are modest, reflecting the relatively slow process of adoption of the innovation and the lag before full-production levels are attained. Two different scenarios were considered: in the "strong barriers to entry" variant the impact on GDP will plateau at a steady-state, corresponding to the estimates of the different types of impact identified above. So, in the simulation of an increase of £1bn in R&D expenditure there results a "steady-state" increase in GDP of £758 million, supporting around 14,000 new jobs.

In reality the profile of the boost to GDP may depend on a range of factors beyond the analysis for this simulation. For example, the impact on GDP will be lower the greater the propensity to import of the sub-sectors of manufacturing that introduces the innovation. Or, the boost to GDP may tend to diminish through time, if foreign competitors mimic the improvement in the technology or if new superior technologies are developed elsewhere. Equally, it may be larger if the sub-sector's innovating have higher private returns and / or higher spillovers than the average for manufacturing as a whole, and it may grow through time if the breakthrough in question confers strong "first-mover" advantages or leads to the development of a self-reinforcing "cluster" of activity in the UK positioned to exploit global export opportunities. The second variant ("weak barriers to entry") shown in figure 34 illustrates how the impact on GDP might decline over time as the benefits of the initial innovation are competed away as foreign producers "learn" or develop the new technology.

Figure 34: Additional annual GDP from £1bn "green" R&D spend in manufacturing

Source: Oxford Economics



4.5 Simulation 2: 15% of energy from renewables by 2020 – winners and losers

Assumptions

This simulation is based on the following assumptions:

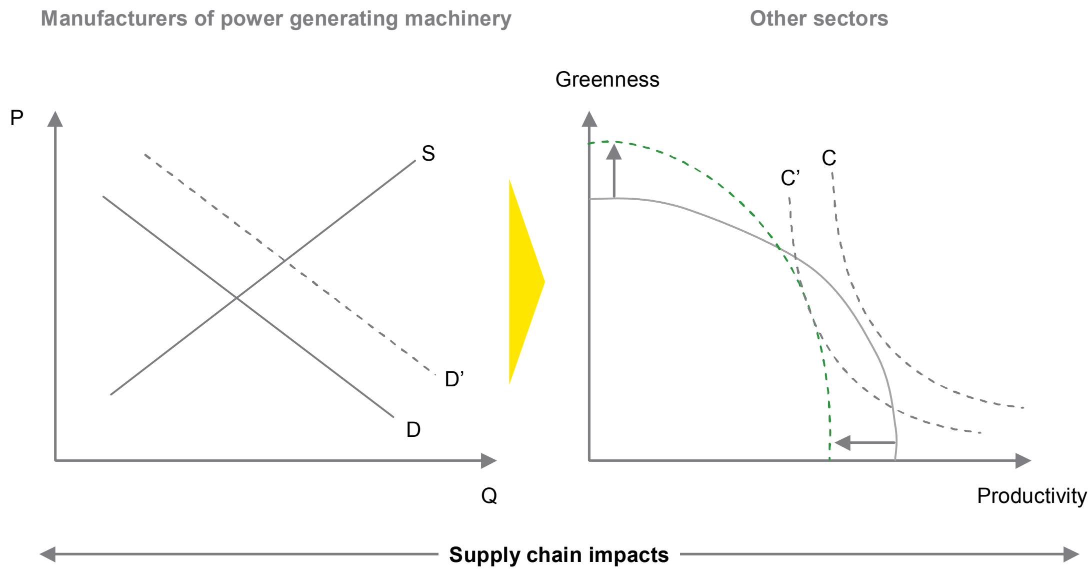
- Increased demand for wind, wave/tidal generation machinery as investment in generating equipment rises.
- Potential demand from other countries also investing in renewable electricity generation.
- This then impacts suppliers of manufacturers of wind turbines, etc.
- The shift to more renewable sources lead to higher electricity prices if government does not subsidise higher generating costs – which could lead to lower energy use and hence a 'greener' economy.
- Overall impact on GDP depends on competitiveness of manufacturers and the scale of increase in energy prices.

The policy being tested sets a target of achieving 20% of the EU's primary energy use from renewable sources by 2020, but does not necessarily imply that a 20% target must be achieved in the UK. With burden sharing across the EU the implication is that there are similar efforts across the EU, that imply the UK achieves 15% of primary energy from renewable sources, up from around 5% in the business as usual scenario. Most of the burden will fall on the electricity sector which will see share of renewable electricity generation rise from 15% in the business as usual scenario to around 40% by 2020

Effects at work

As shown in figure 35 a move to renewable energy shifts out the demand curve for manufacturers of power generating machinery (this is equivalent to a regulatory change). The size of this shift depends on the size of investment involved, the extent of the shifts to renewables in other countries and the competitiveness of UK manufacturers of power generating machinery.

Figure 35: Impacts from increased use of renewables in electricity generation



The higher energy prices needed to make renewable energy economically viable reduces productivity in other sectors; it does, however, improve greenness of production as electricity used is now greener. Other things being equal there are therefore negative consequences for the competitiveness, profitability and output levels of electricity consuming industries.[43] This is the opposite impact to that illustrated in the manufacturing sector example. In the renewables example the customer sectors and the final consumer suffer higher costs, whereas in the manufacturing sector example the change (to greener engines) lowers costs for the customer sectors and the final consumer. This illustrative analysis, rather than indicating the desirability of one policy initiative against another one, serves to illustrate the importance of assessing the impact on prices, costs and incentives in downstream sectors in calculating the net impact on GDP.

As in the manufacturing sector example, there are direct effects from the expansion of the renewables sector which filter through the industry's supply chain. Similarly there are also some crowding out effects in other sectors driven by the use by the renewables sector of scarce resources that are not then available for alternative uses.

Calibrating the effects

In this simulation two variants were considered; the first where the UK acts unilaterally to meet renewable targets and the second where the EU as a whole also undertakes strenuous efforts to achieve renewable targets. These variants are based on work undertaken for BERR in 2007.[44]

In the first variant UK energy prices have to rise by around 20% in order to make renewable energy generation viable, with most of this accounted for by a substantial rise in electricity prices (30%). This price increase hits profitability of production and erodes competitiveness, as well as having short-run demand impacts. In both scenarios, the impact of higher energy prices on consumers' real incomes, on firms' profits and on their competitiveness leads to weaker demand in the short-run. Although the monetary policy authority (Bank of England) would be able to partially manage weaker demand by cutting interest rate in the medium and long run, the effort of reducing carbon emissions through higher renewable energy also leads to lower potential output, as firms shift to a production technology that is greener and uses less energy but is less productive, and therefore relocate abroad some of its lost production where carbon is less expensive.

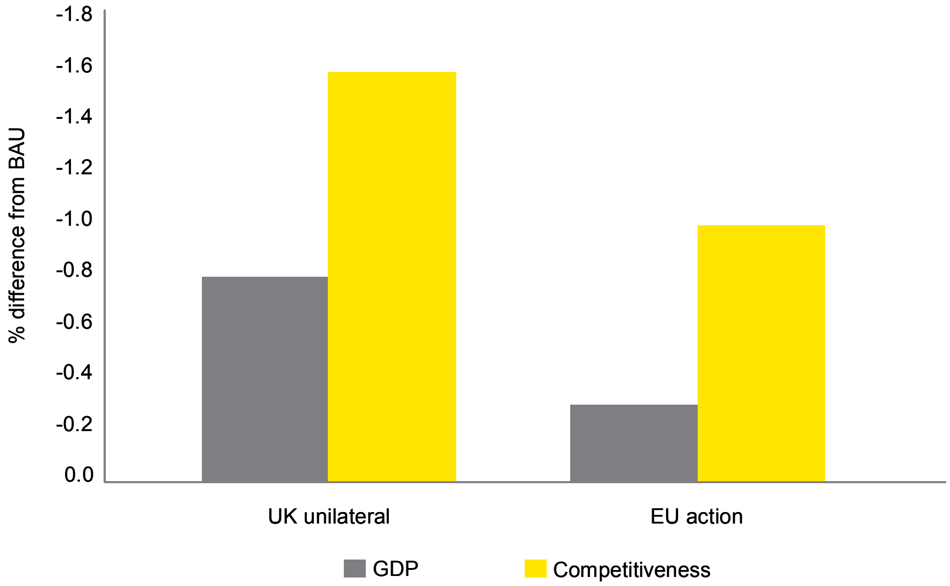
In the second whole EU scenario implying that the competitiveness impacts are smaller, i.e., energy prices also rise in the rest of the EU, although there is still a competitiveness deterioration vis-à-vis the rest of the world. In addition, the cost of (scarce) resources used to increase renewable generating capacity is likely to rise even further in this variant due to the greater level of EU spend – as all EU countries are striving to meet the same target.

The impacts of the two variants are shown in figure 36 and compare the levels of GDP and competitiveness with a baseline scenario where no efforts are made to meet the renewables targets.

[43] Though it is not shown in the Chart there may also be scope for rightward shift in the supply curve – that is more supply at any given price – if economies of scale are present in the generating equipment industry that would mitigate some of these negative impacts.
[44] "Report on modelling the macroeconomic impacts of achieving the UK's carbon emission reduction goal", Oxford Economics, 2007.

Figure 36: Impact on GDP and competitiveness of the UK increasing renewables share of energy to 15%

Source: Oxford Economics



Supply chain gains

In sectoral terms the industries that are hit hardest by a move to renewables are those (typically in manufacturing) that make intensive use of energy in their production technology, and those that have a high price elasticity of demand for energy. Those that are hit least hard are the sectors (typically in service industries) that make relatively little use of energy in their production process and which have relatively low price elasticity of demand for energy.

For example, the basic metals sector, which makes very intensive use of energy in its production technology, has a high price elasticity of demand for energy, and is highly exposed to international trade, is by far the worst hit sector in all scenarios. By contrast, the least affected sectors - communications services and business services - thanks to the low share of energy in their production technologies and their relative insulation from international competition.

There are however opportunities that offset some of the GDP loss from moving to renewables. The size of these impacts broadly depends on the extent to which the UK captures the manufacturing of the equipment required to generate power from renewable sources. For example[45] , the investment in plant and equipment required to increase the generation of electricity from renewable sources by 60 TWh to allow 15% of UK energy to be sourced from renewable sources is estimated at approximately £3bn or 0.2% of GDP per annum. Thus, before allowing for second round effects in the supply chain, if the 30% of this equipment[46] was provided by UK sources around 7.5% of the GDP loss from the higher cost of renewables in the UK only variant and around 20% in the whole EU variant is recouped from increased value added by the equipment suppliers. For the UK variant, Figure 37 illustrates the benefits to the key sectors in the supply chain on the assumption that the spending on equipment is split 50:50 (£450m each) between the mechanical power equipment and electrical generators and motors sectors.

[45] Internal Ernst & Young estimates.
[46] Internal Ernst & Young estimates.

Figure 37: Supply chain impacts from increased renewables investment

Source: Oxford Economics

Sector	£m
Mechanical power equipment	154
Metal forging, pressing etc.	111
Electric motors and generators etc.	71
Electronic components	71
Iron and steel	55
Metal castings	45
Other metal products	24
Electrical equipment	24

As the renewables investment effort takes off in both the UK and in the rest of Europe one of the key challenges will be overcoming supply bottlenecks for specialist inputs – both physical and human. While identifying these requires detailed and close analysis of specific supply chains that is beyond the scope of this exercise, indications of how the UK is placed in some key supply sectors can be gleaned from detailed trade statistics. Figure 38 illustrates the current level of exports and the net trade position and the revealed comparative advantage (RCA) index in sectors and sub-sectors likely to be impacted in the drive to meet the renewables target. Even within this partial cross-section of supply industries it is clear that the UK's position as a supplier varies considerably.

Figure 38: RCA for sectors likely to be affected by expansion in renewables

Source: International Trade Center

	Export value 2006 ($m)	Net trade ($m)	RCA index
Electrical parts of machinery/app, nes	669	169	3
Electric generating sets and rotary converters	1,563	1,175	2.9
Electrical mach&app having individual function, nes	1,459	573	1.2
Electric transformer, static converter (for example rectifiers)	1,153	-223	0.6
Electric motors and generators (excluding generating sets)	654	-263	0.5
Articles of iron & steel	5,933	-1,737	0.8
Iron & steel	9,437	2,103	0.8

4.6 Simulation 3: Chemicals – shift to greener production processes builds non-price competitive advantage

Assumptions

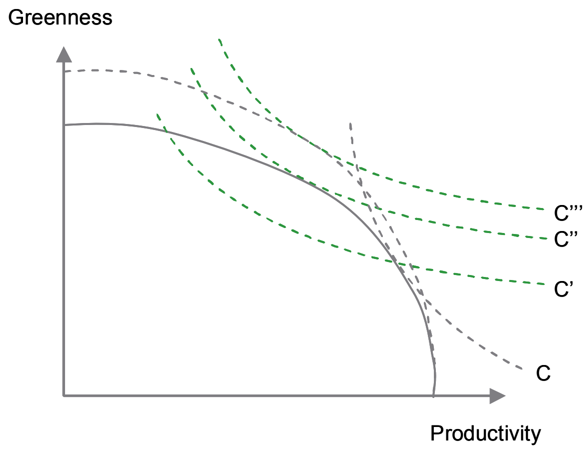
This simulation is based on the following assumptions:

- Greener production driven by capital expenditure provides a non-price competitive advantage.
- UK chemical sector expands relative to 'business as usual' scenario.
- This then has an Impact on supplier & customer sectors.
- Increases overall output.

Effects at work

In this simulation there are two key effects at work. Firstly, changing tastes increase the preference for 'green' products. This could be in the form of final consumers preferring products that can demonstrate a lower impact on the environment, and/or could be from producers further down the value added chain whose preferences move to favouring greener inputs. In turn, these changed preferences could either be the result of spontaneous concern for the environment by consumers or the result of government sponsored educational programmes. As shown in Figure 39 consumer tastes shift towards more greenness at the expense of less productivity, increasing the incentive to invest in more green production, pushing out the frontier representing the feasible combinations of greenness and productivity. In turn, the combination of new preferences and change in production methods have impacts up and down the supply chain.

Figure 39: Impacts from development of a non-price competitive advantage

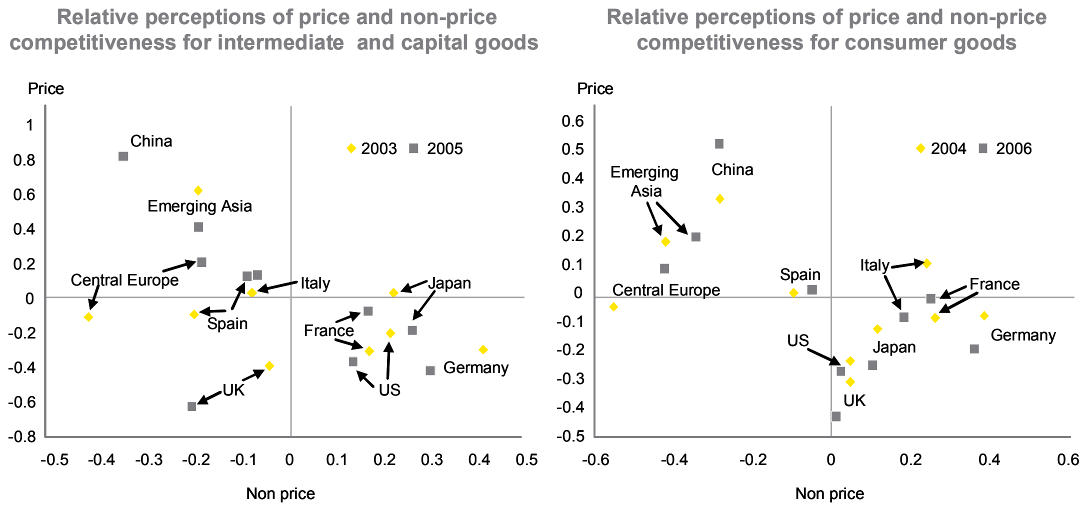


Calibrating the effects

Most developed countries depend on non-price factors for competitiveness. These include factors such as quality, reliability and customer service. The Paris-based Centre d'Observation Economique conducts a biannual survey of perceptions of price and non-price competitiveness of manufacturing. Unsurprisingly, the emerging markets score more highly on price competitiveness (the vertical axis in Figure 39) than all of the developed countries covered. However, developed countries, led by Germany, tend in general to score more highly on non-price competitiveness. The picture on non-price competitiveness is, nevertheless, mixed in the case of intermediate and capital goods, with some developed countries such as the UK, Spain and Italy not scoring significantly better than some emerging markets in Central and Eastern Europe or Emerging Asia.

Figure 40: Price and non-price competitiveness of major exporters

Source: COE

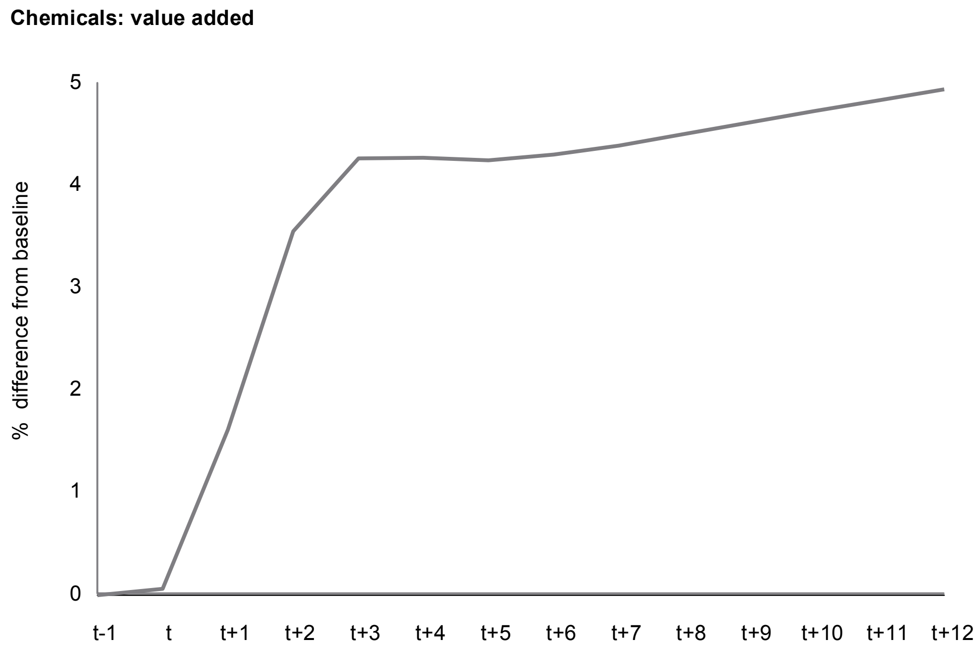


In this simulation, we assume that 'greenness' becomes an important factor determining the non-price competitiveness of chemical producers – as consumer tastes change, they differentiate products not only through factors such as quality, but also by their environmental impact. Specifically, we assess the impact on output in the chemical's sector resulting from a 5% improvement in non-price competitiveness. Similar exercises and processes could be repeated for other industrial sectors and further research would be necessary to link the actual effect of reducing the environmental impact of production on a sector's competitiveness – a 5% gain is an illustrative example.

Improved competitiveness in the chemicals sector increases demand at home and abroad as UK chemical products become more attractive compared to foreign competitors. Output takes some time to respond to the improved competitiveness as firms will only respond with a lag to 'greenness' becoming an important factor for competitiveness – it takes time to increase production. Assuming a 5% gain in overall competitiveness suggests that the chemical sector could boost output by nearly 5% over the following decade. It is important to note that we have assumed the competitiveness gain is permanent – something akin to 'first mover advantage' – but the gain could be gradually eroded if other countries follow suit.

Figure 41: Impact of 5% competitiveness gain on production of chemical

Source: Oxford Economics



Supply chain gains

As output in the chemical sector rises, then this also increases demand in sectors that supply the chemical industry. Figure 42 ranks the sectors within the chemical sector's supply chain according to the increase in output that results from increased production of chemicals. This illustrates that the benefits spread widely through the economy with computers and utilities, in particular, gaining. Overall, GDP in the UK is boosted by 0.1% after 10 years if the chemical's sector is able to boost competitiveness by 5% by reducing the environment impact of its production process. In terms of jobs the chemical sector expands by around 6,000.

Figure 42: Supply chain impacts from increased competitiveness in chemicals – impact of improved non-price competitiveness in the Chemicals sector

	Impact % on GVA after 10 years
Chemicals	4.6
Computers	0.3
Utilities	0.2
Extraction	0.2
Total GDP	0.1
Precision equipment	0.1
Paper	0.1
Basic metals	0.1
Financial services	0.1
Wholesale	0.1
Communications	0.1
Retail	0.1
Mechanical engineering	0.1
Food	0.1
Business services	0.1
Metal products	0.1
Transports	0.1
Hotels and restaurants	0.1
Constructions	0.1
Motor vehicles	0.1
Printing and publishing	0.1

4.7 Simulation 4 – Financial services, impact of carbon trading

Financial services have a pervasive role to play in the development of a greener economy. Already there are specialists organisations, divisions and funds tasked with channelling capital to profitable green business opportunities, while sustainability and environmental impact are among variables that are likely to be involved in everyday investment and lending decision making. Enhancing and developing the City's skills in environmental aspects of investment will continue, therefore, to be a key aspect of maintaining London's position as the pre-eminent global financial centre.

The emerging carbon market is one identifiable green aspect of financial markets in which the UK (London) is well placed to participate. The international scope of the market and the specific trading and settlement skills provide the UK with clear advantages in this area. And the effective pricing of carbon emissions is likely to be a key driver to the increased use of renewables and might thus provide an additional offset to the negative impact to GDP from the switch to renewables.

The international carbon market is embryonic, but it is growing fast. The Financial Services Authority puts the EU ETS market at €35 billion in 2006 and[47] according to Climate Exchange plc[48] over the first eight months of 2007 the European Climate Exchange saw 654,819 contracts exchanged, up from 256,852 in the same period of 2006, a growth of 155%. This is equivalent to 0.7% of the volume of equity market transactions over the same period. The consensus[49] is for continued very fast growth in the trading of carbon contracts, with step changes as the range of industries covered by the EU ETS expands and the initiatives foreshadowed by the Bali conference come into effect. One US study[50] by

[47] "The emissions trading market: risks and challenges", Financial Services Authority, March 2008
[48] "Climate Exchange plc, Interim Report for Six Months to June 2007"
[49] "The emissions trading market: risks and challenges", Financial Services Authority, March 2008
[50] New carbon Finance, http://www.newcarbonfinance.com/download.php?n=New_Carbon_Finance_Press_Release_US_Carbon_Market2.pdf&f=fileName&t=NCF_downloads

New Carbon Finance suggests a $500 billion market in Europe and a $1 trillion market in the US by 2020, while the European Energy Exchange[51] expects medium term market growth of the order of 35% per annum.

As an illustrative exercise, it is possible to construct estimates of the contribution of carbon trading as an activity on UK GDP[52] in the period to 2020. We have developed two variants based on different approaches to projecting growth. The common assumptions behind the variants are:

- Current carbon trading currently represents 0.35% of UK based market transaction activity.
- Growth in carbon trading is fastest in the early years of the period, but with a step change in 2012 as the scope of the EU ETS expands.
- Trading activity represents 23% of the output of the auxiliary financial services sector – in line with the share of 'security broking and fund management' in auxiliary financial services employment.
- Productivity levels are uniform across the auxiliary financial services sector.

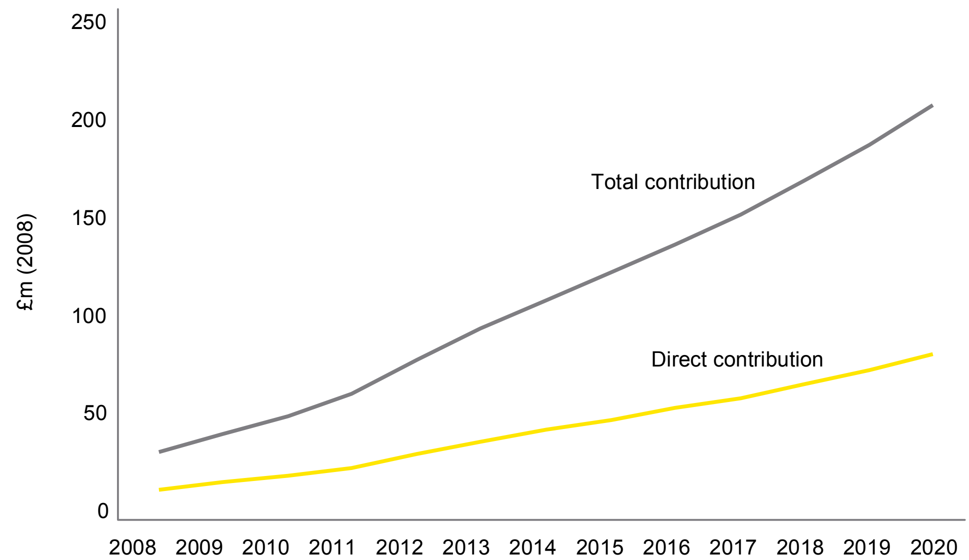
Variant 1

The first growth variant is based on the New Carbon Finance projection. Assuming London captures 80% of the projected European market and 20% of the projected US market, the market in London will be worth $600 billion (£300 billon) per annum by 2020, a growth rate of 17% per annum over the period to 2020.

As shown in the chart, on the basis of the common assumptions, carbon trading currently directly contributes £12 million to GDP, rising to around £80 million (in 2008 prices) by 2020. Taking account of indirect and induced effects the growth in the total contribution to GDP is from £30 million in 2008 to £210 million, equivalent to 0.01% of UK GDP by 2020.

Figure 43: Variant 1 – Contribution to GDP from carbon trading

Source: Oxford Economics



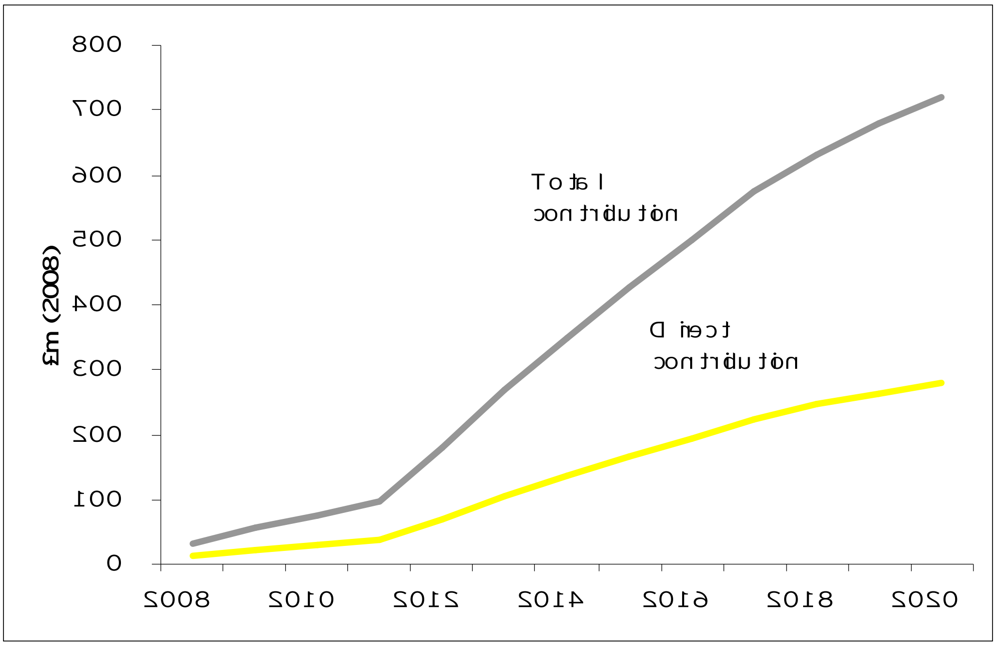
[51] European Energy Exchange - Emissions Trading Cooperation Press Briefing – London, 7 November 2007
[52] Depending on its level the price of carbon will potentially have significant levels on the level and rate of growth of GDP (through increases in energy prices, particularly electricity price). These are not taken into account in this exercise.

Variant 2

The second variant assumes a growth rate of 30% per annum over the period to 2020 in carbon trading activity in the UK. This value compares with the most aggressive scenario laid out by the European Energy Exchange of growth of 35% per annum.[53] In this scenario the direct contribution of carbon trading to GDP, assuming the same share of the EU and US markets captured by the city of London, rises to around £280 million (in 2008 prices) per annum by 2020. Taking account of indirect and induced effects the growth in the total contribution to GDP is from £30 million in 2008 to £720 million, equivalent to 0.05% of UK GDP by 2020.

Figure 44: Variant 2 – Contribution to GDP from carbon trading

Source: Oxford Economics



4.8 Conclusions

The impact of changes in specific sectors that build on the UK's comparative advantage in those sectors whilst at the same time helping to move the economy towards a low carbon economy are widespread. The final net impact on GDP will, however, ultimately depend on the type of change that occurs. The development of new solutions that reduce the environmental impact of delivering goods and services has the potential to boost UK GDP at the same time as greening the economy. However changes that, while resulting in low-carbon processes and production, have pervasive cost implications will tend to have a net negative impact on GDP, as the offsets from increased production in a small number of sectors are overwhelmed by the negative impact on growth elsewhere. However, in both types of example there are sectors up and down the supply chain from the sector driving the change that will benefit, implying that the shape of the UK economy will change from what would have prevailed if there had been no change towards a low carbon economy.

Issues such as the extent to which the UK takes unilateral action to green the economy, the strength of the UK supply chain across a wide range of industries, the degree to which R&D success spills over into other parts of the economy and the ability of international competitors to replicate UK success in innovation are all critical factors in determining how the change in one or a number of sectors influences the path taken by the economy as a

[53] European Energy Exchange - Emissions Trading Cooperation Press Briefing – London, 7 November 2007

whole. The factors driving the change towards a low-carbon economy are also important to determine the final impact on the economy: changes driven by international fuel prices for example will provide, all other things being equal, a relatively higher benefit than those driven by unilateral regulation. Whether unilateral regulation that anticipates a global movement in the same direction can over the long term produce net economic benefit should be the subject of further analysis.