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Headline findings

1. There is currently a window of opportunity to put the UK economy decisively on a trajectory towards low-carbon prosperity, resource security and environmental quality : interest rates are low and, with still under-utilised resources, the benefits of stimulating directed investment can be large.

2. A green economy strategy can strengthen the UK economy by addressing major long-term weaknesses, particularly under-investment in infrastructure and under-performance in innovation . A credible, long-term strategy, supported by environmental tax reform, can thus deliver a more soundly-based recovery, economically as well as environmentally.

3. Government should take a more proactive, strategic approach to driving green innovation. A green industrial strategy can help to strengthen the UK innovation system and secure comparative advantage in key sectors and areas of technology that enhance resource productivity, but global competition in these areas is intensifying.

4. Government should adopt a clearer approach to prioritisation of key infrastructure projects, and ensure that infrastructure investments are compatible with long-term green economy objectives. Going beyond the undifferentiated infrastructure list in the UK Infrastructure Plan, the Government needs to identify what green infrastructure investments are required and prioritise these accordingly in order to ensure policy clarity and credibility.

5. A new information infrastructure is required to facilitate the evolution of a greener economy. Current national accounting practices and corporate reporting rules were largely developed at a time when the economic and social importance of environment and resource issues was less well recognised than it is today. Government should develop comprehensive natural capital and material flow accounts for the UK economy.

1. Introduction

The UCL Green Economy Policy Commission (UCL GEPC) brought together a diverse group of academics with expertise in economics, the built environment, infrastructure finance, political science, innovation, and resource efficiency to consider how the UK can implement policies that will support a green economy. The GEPC also commissioned additional evidence and research and held a number of stakeholder meetings in order to contribute and seek responses to the Commission's conclusions and recommendations.

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Few people disagree that these issues are important, but there is ongoing debate about the priority that should be accorded to them, particularly as the economy remains fragile following the recession. Progress towards these three key elements remains patchy. Our analysis indicates that there is a clear rationale for the government to adopt a green economy strategy that drives a green recovery.

3. Rationale for a green economy strategy

The primary rationale for a green economy strategy is a concern for the environment, recognising that the environment underpins the long-term welfare and prosperity of human society. In the long term, excessive environmental damage poses unacceptable risks to economic and social welfare. Environmental goods and services, whilst essential for a successful economy, are difficult to value in purely monetary terms, and without a coherent green economy strategy they will be neglected by the operation of markets. A strategy for a green economy therefore aims to catalyse a direction of travel, moving the economy systematically towards increasing its resource productivity, reducing its greenhouse gas emissions, and maintaining its stocks of natural capital in a way that generates satisfying work and high living standards. Such a strategy is necessitated not only by the need to mitigate climate change but also by the vulnerability of the economy to degraded natural capital and to resource constraints and associated price volatility – in recognition of the importance of the environment and of natural resources in directly supporting wellbeing.

Many of the structural reforms required for a green economy, as discussed in this report, would be necessary even if the environment was much less of a concern. It is widely accepted that the UK economy has to address long-term structural problems – particularly chronic patterns of under-investment in both infrastructure and innovation. The measures we propose will help to address these long-term structural economic issues. If the long-term importance of decarbonisation and other environmental goals are accepted, then it makes sense to make such structural reforms in a way that drives the transition to that long-term goal: a low-carbon, resource-efficient green economy.

There are short-term costs, but these are lower than is often supposed. It is clear that, in the short term at least, there are costs to environmental policy, and there will be losers as well as winners. But the predicted costs of environmental policy have often been overestimated in the past. Estimates of future costs are often inflated by industry lobbies keen to avoid regulation; furthermore, innovation in response to regulations reduces the costs of policies once they have

functioning market. Government plays a fundamental and inescapable role in defining and framing the market. The language of whether government should or should not 'intervene' in markets misses the point – government is an unavoidable part of the economic structure.

A key conclusion of the UCL GEPC is that the UK Government can and should take a bolder and more proactive approach to delivering a green economy, particularly in those areas – innovation and infrastructure – in which it is increasingly recognised that government's role is more than fixing failures. A green economy strategy is required that inspires confidence in a stable growth pathway: as shown in Figure 2, it requires policy credibility as the essential encompassing characteristic of government action, in order to give confidence, especially to private investors, over the future direction of economic development. We argue that policy credibility is expressed through long-term objectives of macroeconomic strategy, industrial strategy and environmental tax reform.

This credibility provides the foundation for the three major conceptual and practical pillars of public-private co-operation which allow the green economy to be constructed: innovation; infrastructure, and the associated investment; and information. One of the principal features of the green economy, as a result of eco-innovation, investment in appropriate infrastructure, and a much enhanced information base on environment and resources, will be continually increasing resource productivity and resource efficiency, which will contribute to economic growth and competitiveness in a world characterised by resource price volatility and risks to resource availability.

These are the ideas and concepts, which, together with the interactions between them and the policies to support them, form the main subject matter of this report.

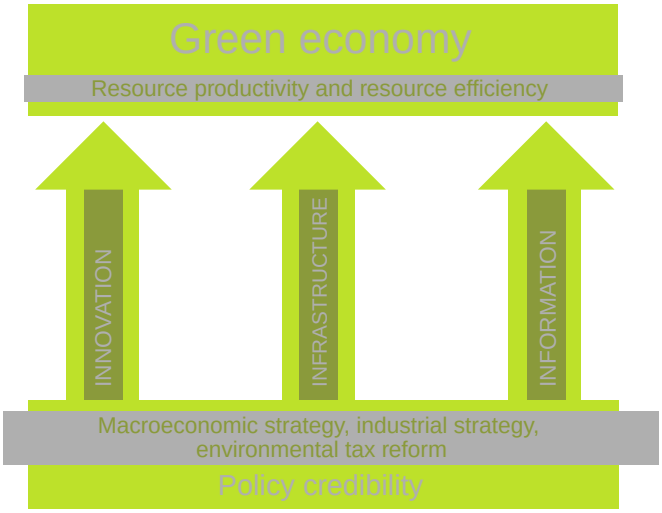

Figure 2: Diagrammatic illustration of essential concepts and relationships in a green economy

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5. The three core ‘pillars’ of a green economy strategy

1. Innovation. It has long been recognised that innovation lies at the heart of economic growth. A key conclusion of the UCL GEPC is that, for innovation to promote resource efficiency and environmental protection, it will need a substantial input from public policy. Appropriate price signals will be an important part of that input, encouraging innovators, entrepreneurs and consumers to develop and adopt technologies that reflect the environmental costs of resource and energy use. But many of the great innovations of the past – particularly in the modern era – have not arisen as the sole result of entrepreneurs responding to price signals. Although the operation of markets has played a major role in the development and deployment of these innovations, so too has public policy, funding early stage research, subsidising demonstration and early deployment, sharing the risks of mass roll out, and creating financial and regulatory institutions that increase market confidence and facilitate the involvement of private investors in new markets.

The details are different for different innovations, technologies and sectors, but the principle is clear. Successful innovation, particularly green or eco-innovation, is the result of intelligent and sustained public-private partnership rather than the exclusive operation of markets. We propose a new green industrial strategy to guide innovation, by both horizontal instruments that give the right incentives right across the economy, and targeted sector-specific policies that focus on the skills and supply chains required for greener products and processes.

2. Infrastructure. Market actors are unwilling and unable by themselves to create the infrastructure that underpins national prosperity. It is also recognised that UK infrastructure is in need of substantial renewal. But by no means will any or all new infrastructure facilitate moves towards a green economy. There are important choices to be made in respect of infrastructures of supply and demand, of energy, water, construction and transport, and of the information and communications infrastructure that will to a large extent determine how they are operated. Government and public policy has a crucial role to play in all the important choices in this area if UK businesses and consumers are not to be locked in to high-carbon, resource-intensive patterns of economic activity that become a growing liability in a world increasingly concerned about, and feeling the effects of, climate change and escalating demands for resources of all kinds. Going beyond the undifferentiated infrastructure list in the UK Infrastructure Plan, the Government needs to identify what green infrastructure investments are required and prioritise these accordingly in order to ensure policy clarity and credibility.

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- The development of long-term patient-finance vehicles for green innovation, by including a green innovation arm within the Business Bank currently being developed within the Department for Business, Innovation and Skills (BIS). This would invest and hold equity in technology-based firms developing new clean technologies.

- Better downstream/upstream alignment: that is, the alignment of downstream policies focused on supporting diffusion of core green technologies (i.e. deployment subsidies) with upstream funding support for technological innovation. The process of innovation is not linear, and ongoing R&D is essential as deployment continues. In the past, deployment subsidies have not been developed with a clear view on how they enable learning and technological innovation.

- Support for innovation in business models: the TSB should develop a small fund for proof-of-concept or feasibility studies for innovative business models, particularly targeting

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Our key recommendation on infrastructure for a green economy is to set out a strategic infrastructure plan that, unlike the National Infrastructure Plan, sets out the criteria on which infrastructure proposals will be judged and prioritises them accordingly. These criteria would include green criteria, enabling a prioritisation of those infrastructures that are required for a green economy (such as sufficient transmission capacity to incorporate renewable electricity into the power system; a 'smart grid' to facilitate its management; and materials management facilities to delay or prevent resources from becoming wastes). They would also encourage the greening of other infrastructures that are not inherently green, such as water infrastructure, ensuring that they are compatible with green economy objectives.

The Green Investment Bank (GIB) has been an important step forward in enabling core green economy infrastructure to be developed. However, with less than £5 billion, its capital represents less than 1% of the UK's anticipated infrastructure investment requirement to 2020[9]. We therefore propose that the Green Investment Bank should be enhanced by:

- Enabling it to borrow (up to £2 billion), through the issuance of green bonds, that would support its lending in its priority sectors of offshore wind, waste management and commercial energy efficiency.
- Increasing its capitalisation by £1 billion to further entrench business confidence in the overall green economy strategy.
- Expanding its remit to include community energy projects (subject to state aid approval), following recent changes in finance availability from private sector sources for these kinds of projects

The Green Investment Bank (GIB) targets infrastructure that is required for a green economy. There is also a well-recognised need to stimulate investment across a much wider range of infrastructure, beyond the targeted scope of the GIB. We therefore recommend increasing public capital spending on infrastructure through the capitalisation of a new National Infrastructure Bank (NIB), and ensuring that this is compatible with a green economy by embedding green criteria in its mandate. The NIB would work alongside the GIB but finance larger infrastructure projects, either as a wholly separate institution or with the GIB sitting as a unit inside the new NIB. In October 2013, the IMF called for the UK to increase infrastructure spending in order to support the recovery – this infrastructure spending should be consistent with green economy objectives.

9 Helm, D. (2009) The challenge of infrastructure investment in Britain, in Caldecot, Helm and Wardlaw (eds) Delivering a 21st century infrastructure for Britain, Policy Exchange.

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Finally, we recommend bolstering the capacity of local authorities to drive green infrastructure locally by enabling the establishment of green municipal bonds and a collective municipal bond agency owned by participating local authorities.

c. Recommendations on Information: creating a new information infrastructure

- Establish a system of natural capital accounts
- Construct detailed material flow accounts
- Develop the information system for investment and supply chain management through a Resources and Environment Reporting Council to develop indicators for resource use
- Improve corporate accounting through the promotion of confidence accounting
- Improve consumer information and its integration into policy packages

Our key recommendation with regard to information for a green economy relates to two major national accounting projects on natural capital and material flow accounts. The Office for National Statistics (ONS) needs to be commissioned to undertake two major data design and development projects:

- the construction of a system of natural capital accounts to increase understanding as to how and where natural capital should be maintained and augmented, and to act as an interface between the economy and the environment, to facilitate the detailed modelling of the impacts of the economy on the environment and the contribution of the environment, resources and ecosystem goods and services to the economy.

- the construction of much more detailed material flow accounts for the UK economy that will track the flow of different materials through the economy, to facilitate their retention of value and their appropriate management at the end of product lives, without which policy makers will not be able to understand how resource use is developing in the UK, and how it should be managed.

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Our recommendations on information, discussed in detail in Section 2, are summarised in Figure 5 below.

	Government	Investors	Corporations
Conventional Information Metrics	System of national accounts; gross domestic product, current account, net exports	COD-VERB[10] framework for investment decisions; investor analysis and reports	Annual report: standard financial metrics and reporting
Environmental and resource (E&R) risk to actors	Climate shocks increase health costs and damage infrastructure; agriculture variability; resource shortages	Damage to, or mispricing of assets in investment portfolios; increasingly large insurance payouts	Increasing resource and waste costs; reputational damage from supply chains
Information required for managing own E&R risk	Comprehensive view of the material basis of the economy, similar to economic national accounts; E&R boundaries and bottlenecks	Investment in different sectors that contribute to environmental damage; E&R 'Big Data'	Own E&R requirements and impacts; supply chain data on key environmental, social and governance (ESG) issues issues; benchmark ESG relating to competitors
Current E&R information disclosure	Environmental accounts; carbon accounting and budgeting	According to Principles for Responsible Investment; ad-hoc research	CSR and sustainability reports; green claims on products; returns to CDP
Proposed E&R information disclosure	Construction by ONS of natural capital and material flow accounts, linked to UK NEA information; monitor resource prices; development of consumption-based accounting	Integration of environmental data into COD-VERB framework; use confidence accounting that provides a risk assessment of asset values	Work with RERC to establish a comprehensive, standardised E&R reporting system, apply the system to supply chains, contribute to SDGs through Global Compact

Figure 5: Information needs for a green economy (see section 2.3.1 for discussion)

10 COD-VERB stands for Cost, Ownership, Disclosure, Value, Existence, Responsibility, Benefits

d. Getting more with less: policies for resource efficiency

- UK policies to increase resource efficiency include: economic instruments, regulations on waste and energy efficiency; facilitation of industrial symbiosis; review of waste definitions and product specification; and intensification of green public procurement.
- EU policies to increase resource efficiency include: harmonisation of environmental taxes; extended producer responsibility; regulations on waste exports; and eco-design.

We make a number of recommendations to increase resource efficiency at both the UK and the EU levels:

- The UK policy mix, shared according to the respective competences of the UK and devolved governments, should comprise:
  - Economic instruments, including maintenance of the landfill tax, year-on-year increase in the aggregates tax, introduction of other resource taxes, incentives for energy efficiency in buildings (e.g. Council Tax or stamp Duty rebates), variable waste charging for households, and deposit-refund schemes
  - Regulations for resource efficiency in a number of areas, including the incineration only of non-recyclable wastes, and improvements in whole-house energy efficiency in buildings subject to extension or renovation.
  - Public facilitation of industrial symbiosis, the process by which industries collaborate to increase resource efficiencies and minimise wastes, by identifying where one industry's by-product materials or unused resources can be used as an input for another industry.
  - Continuing review of waste definitions and product specification through the Waste Resource and Action Programme and the Environment Agency
  - Intensification of green public procurement.

- At the EU level the UK Government should support, and contribute to the development of, policies for:
  - More ambitious harmonisation of environmental taxes, through revision of the Energy Tax Directive, and the calibration of taxes on energy into both energy and carbon components
  - Intensification of extended producer responsibility, including product passports

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– In the long-term, the main international emitters outside the EU must be brought on board through international treaty . Europe should announce an intention to set up a coalition of countries, persuaded to action by the prognoses by mainstream climate science, to introduce policies for stringent abatement of GHGs, and a system of border tax adjustments, so that countries that do not adopt an internationally comparable carbon pricing system pay for their carbon emissions through tariffs.

– With a schedule for border tax adjustments in place the UK should campaign for 100% auctioning of EU ETS emissions permits at the earliest possible date.

• The government should gradually increase VAT on household energy use , the low rate of which constitutes the UK's largest single environmentally perverse subsidy, while giving a Warm Home Guarantee to low-income households through an increased Warm Home Discount until such time as their home can be made properly energy efficient through the use of the VAT revenues.

Finally, index-linked policy-performance bonds , which increase the interest payable to the extent that the government fails to meet its environmental performance targets, would provide investors with some confidence that government is serious about policy goals. Much as inflation-linked bonds have been used to demonstrate a government's commitment to tackling inflation, carbon-linked bonds could be used to bolster confidence that government is serious about tackling climate change. Similar mechanisms could be used for forests, and other areas of environmental concern.

8. Final remarks

As the UK economy emerges from recession, the direction it takes in recovery will largely determine whether it is robust in a world increasingly characterised by concerns about climate stability and resource availability, and generates growth and competitiveness through addressing those concerns; or whether it is increasingly desperately trying to sustain unsustainable sources of prosperity. The UK Government has a major role in determining which of these futures is the dominant experience of its people. We believe that the adoption of the package of recommendations we outline above would put the UK well on the way to achieving a green economy, which would in turn make a major contribution to the present and future prosperity, security, and quality of life of the UK population.

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1.1 Definition of a green economy

A green economy is more easily characterised than defined. It has very low levels of carbon and other emissions to the atmosphere, and does not pollute the land, fresh water or seas. It also has very high levels of resource productivity, which means that it delivers high levels of human value, measured in money or other terms, for low throughput of energy and material resources. Such an economy results in aggregate human activity remaining within local and planetary environmental limits, such that it does not damage human health, deplete renewable resources, or cause climate change or ecosystem degradation, because it takes due account of the values and human benefits which a stable climate, high environmental quality and resilient ecosystems provide. The concept therefore intersects with two important high-level public policy agendas – those on environmental sustainability and on 'beyond GDP'.

The green economy is an ideal conception in that it does not exist, strictly as it is as defined above. Nor, as any environmental economist knows, is it likely that zero pollution is 'optimal' in terms of human welfare. The practical value of the concept is that there is now a whole host of fairly well understood indicators that can measure progress towards this ideal. Increasing the economy's resource efficiency and productivity, and reducing its environmental impacts[11], can be a policy objective the success or otherwise of which can be monitored and measured.

1.2 Rationale for a green economy

On current trends, the economic and social prospects for the 9 billion or so people projected to be living on planet Earth in 2050 are characterised by enormous and unprecedented risks. Scientific analysis is increasingly calling into question the ability of the Earth's natural systems to provide the food, water and energy that humans need to survive, let alone thrive, in a context of climate change and growing stress on ecosystems and biodiversity[12]. This situation has been created and is exacerbated by social and economic aspirations that identify 'the good life' with ever greater consumption of food, water, energy and materials of all kinds. These aspirations are shared by the great majority of the world's people, whatever their level of income and wealth.

11 Whether resource use and environmental impact should be reduced absolutely or relatively depends on the resource and impact in question, and is a matter involving both scientific analysis and social and political judgements about complex notions of sustainability and human welfare.

12 IPCC 2013. Climate Change: the Physical Science Basis. Draft Working Group I contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Geneva. MEA (Millennium Ecosystem Assessment) 2005 Ecosystems and Human Wellbeing: Synthesis, Island Press, Washington DC, UNEP (United Nations Environment Programme) 2012 Global Environment Outlook (GEO) 5, UNEP, Nairobi, http://www.unep.org/geo/pdfs/geo5/GEO5_report_full_en.pdf

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With current patterns of economic activity – of production and consumption – not only does it seem most unlikely that the aspirations of most of these people can be satisfied; it seems quite possible that climate and ecosystem change will undermine the basic provisioning, especially in relation to food and water, of an increasing number of societies round the world, with incalculable economic and social consequences. Early signs are clear to see: extreme and disruptive weather events are regularly in the headlines, and over the past decade growing demand from large developing economies such as India and China has spurred a marked reversal of century-long commodity price declines[13].

The potential costs associated with over-stressing natural systems at a global scale are enormous, but they are also uncertain. Doubtless innovation in response to prices signalling scarcity will make easier a transition to a less resource-intensive, low-carbon economy, but active

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There is no credible long-term economic trajectory that is high growth and high welfare, and that also exhibits increasing resource use and environmental degradation. Such growth may persist for some time in some places, but increasingly its impacts on the environment and resources will either reduce the welfare it generates (as the Chinese are discovering with air pollution) or increase resource prices and price volatility, or set off a global grab for or hoarding of resources that undermines the foundations of growth and economic security[14].

Faced with the unprecedented situation of high and still growing human population, of whom a large and increasing number now possess the economic and technological means and the desire to become affluent middle-class consumers, there is mounting recognition that economic

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1.5 Why now? The case for urgency in green economy policy

In light of the UK's continuing economic difficulties, it is inevitable that questions are raised about whether now is the right time for pursuing a green economy strategy. The answer – perhaps surprisingly – is that now is exactly the right time for pursuing such a strategy. Three reasons underpin this conclusion:

First, the information and communication technology (ICT) revolution and globalization are reshaping the opportunities for growth and transformation – and in particular the opportunities for achieving a greening of the economy. ICTs are the main enabling instrument of sustainability, hugely expanding abilities to understand and influence the web of relationships between human society and the natural environment, and enabling far greater levels of energy and resource productivity than have previously been possible. Internet access is the social, economic and geographic frontier of the global market and introduces a whole new range of possibilities for sustainable production and consumption patterns. However, while ICT can enable innovation across a wide range of sectors and products, from smart-grids to special materials, from redesigning products for durability and upgradeability to reducing the need for transport, its deployment for these purposes again requires public policies that set a clear direction, enabling convergence and networking to lead to synergies in suppliers and markets, increasing the profitability of the whole network. Markets alone cannot reach that outcome; an active government can.[16]

Second, the urgency of dealing with environmental problems has become acute. This presents both an environmental imperative and an economic opportunity, as already discussed: as other countries too begin to address environmental problems, the size and scale of markets for environmental goods and services will increase. Once enough players (governments, cities, businesses) are transitioning to resource efficiency, the competitive incentive for others to move the same way and invest in this sector increases. Early movers will be best placed to benefit from those investments.

Third, the difficult macroeconomic conditions that the UK is experiencing, even with early signs of recovery, could be much improved by a policy that gives investors confidence about the direction of infrastructure, business and industrial development over the coming decades. Government credibility about its determination to make the transition to a resource-efficient, low-carbon economy will allow the UK to cut costs and harness innovation to

16 Carlota Perez (2013) Innovation systems and policy for development in a changing world, in Fagerberg, Martin and Andersen (eds) Innovation Studies: evolution and future challenges, Oxford: OUP.

foster competitive advantage in a number of fast growing new markets. The best time to send a clear and credible steer to private investors is now, when interest rates are low, unemployment is relatively high, and the private sector is holding back on investment and sitting on substantial surplus saving. It is often argued that the short-term macroeconomic merit of an investment, in terms of what constitutes a good economic stimulus, can be judged against established criteria. These include tests on whether a public investment is timely, temporary and targeted. Although these are important, historical evidence suggests a more important criterion is the ability to generate private sector confidence in profitable and enduring new markets. Mixed or muddled signals deter nervous investors, particularly in an uncertain economic environment like the present. A macroeconomic growth strategy for a green economy needs to deliver a clear, credible and long-term message that can galvanise early private investment and jobs in LCEGS

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The evidence suggests that the short-term stimulus properties of green investment are not dissimilar to those of alternative investment measures, and far greater than policies which do not attempt to put surplus saving to productive use[17]. This means that overall, the decision as to which sectors are most suitable for stimulus investment should be based not on estimates of differential short run multipliers but on their long-term economic legacy. Digging up holes and refilling them makes for a bad investment choice when there are so many other alternatives, regardless of thetive user(sh

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involving GGGI, UNEP, the World Bank and OECD, policymakers have

struggled to articulate coherently and consistently the choices, trade-offs, costs and benefits involved in the ideas of green growth and the green economy. The principal objective of UCL's Green Economy Policy Commission is both to clarify these issues and make policy suggestions as to how the UK should position itself to derive maximum benefit from growth in the green economy worldwide.

The implications for economic growth of this transition to a resource-efficient, low-carbon economy are still unclear.

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the insights from behavioural economics that can inform policies to encourage people to adopt greener lifestyles. The next two sections discuss the crucial role of innovation in driving towards the green economy, and the no less important subject of the infrastructure that is required to create and underpin it, and how the investment to create that infrastructure may be mobilised. This is followed by a section that looks in more detail at the opportunities and policies for resource efficiency. The concluding section places the preceding discussion in the context of a macroeconomic policy that can use the opportunities offered by the green economy to help reduce the budget deficit and stimulate economic growth in the short term as part of a long-term green economic strategy.

Information for policymakers, investors, producers and consumers

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Information for policymakers, investors, producers and consumers

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Introduction: building a information infrastructure for a green economy

The availability of sound information is crucial for sound public policy and for the effective operation of markets. Public policy in its turn plays a major role in shaping the availability of environmental and economic information and the way in which it is collected and communicated in statistics, accounts and labels. Government's role in shaping the 'information infrastructure' for a green economy therefore requires explicit attention.

Markets are themselves powerful mechanisms for assimilating and communicating information[23] The millions of decisions made by firms, consumers and governments are reflected in and influenced by prices, which provide information about the relative scarcity or abundance of different goods, services and commodities and about the demands for them. Financial and stock markets assimilate and provide information about the prospects of companies and industries. Measures that improve the functioning of markets – such as environmental taxation that corrects market failures – can thus also be seen as information measures, since they embody within prices information about the scarcity of environmental resources and the limits to environmental sinks.

Information economists have increasingly examined the ways in which public policy is required to ensure information is produced and disclosed in ways that benefit society as a whole.

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performance. Their report[28] has influenced many politicians including the UK Prime Minister, who asked the Office for National Statistics (ONS) to recommend measures of national wellbeing[29].

The Commission makes many recommendations, three of which are set out here. Firstly, it advocates less focus on 'production' and more on people's perception of their wellbeing, which in practice means greater consideration of life satisfaction and income distribution. Secondly, it emphasises the importance of the stock of natural and manufactured capital as the lead indicator of the long-term viability of the economic project. Thirdly, it notes insufficient regard is paid to economic volatility and people's risk aversion. Wellbeing is strongly influenced by worries pertaining to issues such as job security, expectations about the future and, by extension, insecurity arising from climate change. All three points are important in relation to the environment and its resources, which make a crucial contribution to human wellbeing, security and prosperity, as well as being the stuff of natural capital and the raw material of manufactured capital.

A second important development over the last few years has been the UN's mammoth Millennium Ecosystem Assessment (MEA)[30]. The treatment of land and biodiversity, and their associated environmental services, has always been a glaring omission from our estimates of a country's wealth. The MEA applies a systematic way of thinking about natural habitats and the services they provide the economy. These services are categorized as: provisioning; regulating; supporting; and cultural. This provides a comprehensive framework for linking the stock of habitat located within an economy to a flow of arising economic services. The Department of Environment, Food and Rural Affairs (DEFRA), keen to use the MEA approach for policy and to value the environment[31], followed up the MEA with another major project, the UK National Ecosystem Assessment (as mentioned earlier), work on which is still ongoing.

Most developed economies have reacted to calls for improved environmental information systems by creating satellite accounts slightly set apart from the core national accounts. A standard methodology is set out for calculating environmental accounts in 'System of Environmental-Economic Accounting Central Framework (SEEA)' which has been revised on a regular basis since 1993[32]. Figure 6, taken from the SEEA, presents the economy as residing within the environment. The economy extracts resources from the environment. Within the economy resources are transformed into goods and services and traded between economic agents. Ultimately they become waste when they are then returned back to the environment.

28 Stiglitz, J., Sen, A. and Fitoussi, J-P. 2009 Report by the Commission for the Measurement of Economic Performance and Soc

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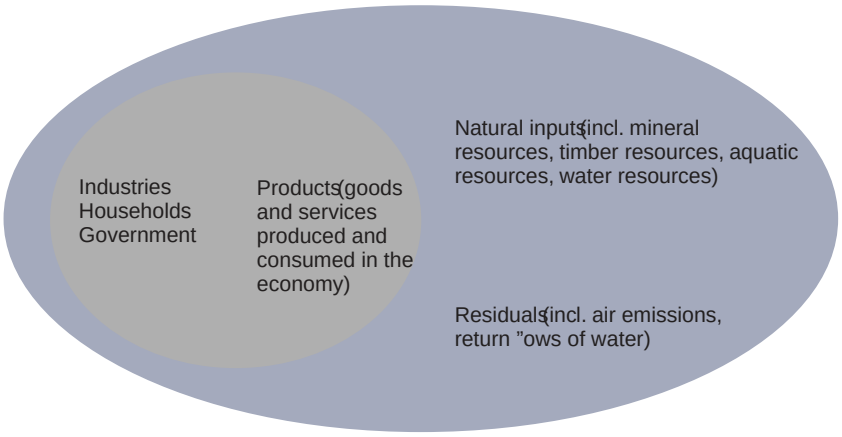

Figure 6: Physical flows of natural inputs, products and residuals

The manual establishes standard approaches to reporting the balance sheets for renewable and non-renewable resources extracted from the environment, for expenditures by business on complying with environmental regulation and for collating data on environmental taxes paid by businesses and households. The ONS has been producing environmental accounts since 1998[33] The basic structure of the accounts has not changed much. The environmental accounts use standard categorisations of industry as their skeleton dividing the economy into as many as 130 industries. This allows the ONS to associate its data on industrial purchases and consumer spending with the physical environmental flow accounts.

The physical flow accounts include or have at some point included:

- Fossil fuels: mass and energy content of different fuels
- Material flow analysis: total mass of mined and imported materials
- Fisheries & forestry: mass of different fish species caught (this account is no longer produced) and forest products harvested
- Atmospheric emissions: emissions of greenhouse gases and gases that give rise to acid rain
- Waste
- Water: mass of water abstracted from rivers and ground-water (now suspended)

33 Vaze et al, (1998) UK Environmental Accounts. (Experimental and pilot accounts were produced before then.)

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The accounts also produce a series of balance sheets that report on the physical quantity of materials still in the environment. These cover fossil fuels and land-area under forest.

Notwithstanding these advances in national environmental accounting, most of which in the UK date from the mid to late 1990s (although some data series have been suspended as noted above), the material flows in Figure 6 are still to a large extent unmonitored compared to the financial flows that they accompany, which are tracked through the accounts in great detail, resulting in sub-optimal decisions about materials management at every stage of their journey through the economy, but especially when they have become 'wastes'. An extensive research programme in the late 1990s, largely funded by the Biffaward Programme on Sustainable Resource Use under the Landfill Tax Credit Scheme[34], began the task of providing a material analogue to the national accounts, but the outputs were partial and fragmented, and the programme was discontinued when the funding stream disappeared. Until such a programme becomes embedded in the ONS alongside the national financial accounts, it will be difficult or impossible for policymakers to understand the UK's resource needs and vulnerabilities, how they contribute to the UK economy, how materials can remain in productive service for longer, or how they should best be managed when products reach the end of their useful lives.

Similarly, the relation between natural capital (the stocks of natural resources and the ecosystems that generate goods and services) and the national economy is poorly understood. Box 2-1 indicates how little progress has been made on developing practical information linkages between this kind of capital and the national economy and how much therefore still remains to be done.

Box 2-1: The State of Natural Capital

The Natural Capital Committee (NCC) was set up in May 2012 following a recommendation in the Natural Environment White Paper published in June 2011 [35]. It produced its first report, The State of Natural Capital, in April 2013 [36]. A few quotations which we reproduce here indicate just how far the UK has to go before it has an adequate information base for the rational management of its natural capital:

34 Key references from this programme are: Biffa 1997 Great Britain plc: The environmental balance sheet, Biffa, High Wycombe, Bucks.; Linstead, C., Gervais, C. and Ekins, P. 2003 Mass Balance: An Essential Tool for Understanding Resource Flows, November, Royal Society for Nature Conservation, Newark/Forum for the Future, London; Biffaward 2006 The Mass Balance Movement, The Royal Society Wildlife Trusts, Newark, Notts.
35 DEFRA 2011 The natural choice: securing the value of nature, the Natural Environment White Paper, Cm 8082, The Stationery Office (TSO), http://www.official-documents.gov.uk/document/cm80/8082/8082.asp
36 NCC (Natural Capital Committee) 2013 The State of Natural Capital, NCC, http://www.DEFRA.gov.uk/naturalcapitalcommittee/files/State-of-Natural-Capital-Report-2013.pdf

The report of the UCL Green Economy Policy Commission

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The conclusions that arise from this analysis are first and foremost that the ONS needs to be commissioned as a matter of urgency to undertake two major data design and development projects:

- Construction of a system of natural capital accounts (SNCA) to increase understanding as to how and where natural capital should be maintained and augmented, and to act as an interface between the economy and the environment , to facilitate the detailed modelling of the impacts of the economy on the environment and the contribution of the environment, resources and ecosystem goods and services to the economy.

- Construction of much more detailed material flow accounts for the UK that will track the flow of different materials through the economy , to facilitate their retention of value and their appropriate management at the end of product lives, without which policy makers will not be able to understand how resource use is developing in the UK, and how it should be managed.

- Linkage of these two accounts to the large amount of useful information about the generation of ecosystem goods and services from the UK NEA .

Without such accounts there is no way that policymakers can even be aware of, let alone manage, the vast and on-going structural changes in the material basis of the UK economy.

Policy makers could also use the environmental and material flow accounts to triangulate between different datasets to reveal information that was otherwise unknown. In the conventional accounts easily assembled data on sales can be used to infer hard-to-observe data. The material flow accounts could similarly combine information on the extraction and imports of materials, with information on recycling to infer how much is locked away in the stock of goods or ends up in landfill sites. Such mass-balance approaches are already used in analyzing emissions from some processes. They could and should be extended to the whole economy. Another important aim of this information, linked to the increasing salience of the policy objective of resource security, would be to understand the economic significance of the price movements of key resources, information that is of considerable importance to both investors and producers. Coherent natural capital accounts would also facilitate analysis and understanding of the direct importance of the

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There are two basic difficulties. The first relates to sectoral classification and supply chains. Environmental goods and services cut across existing sectoral definitions (for example, organic agriculture is embedded within the wider agricultural sector; renewable electricity generation is embedded within the wider power generation sector). Beyond this, the supply chains are even more difficult to identify: a true picture of the importance of green activities in the economy might identify the portion of steel production that is dedicated to wind turbine construction, for example. The second major problem relates to judgements about the 'green-ness' of particular goods and services. This is not a problem for identifying economic activities for which the primary purpose is a reduction in environmental harm, such as the production of catalytic converters. But it becomes more difficult when one considers goods that have much higher levels of energy or material efficiency. For example, a Toyota Prius is certainly considered an 'environmental' good in the context of a road transport sector dominated by vehicles with much less efficient drivetrains. But as road transport emissions fall and cars become cleaner, the day is likely to come when a Prius is a relatively dirty vehicle. Inclusion of such 'adapted goods' is a challenge for clear measurement[41].

Since 2009, BIS has annually published a dataset that provides one estimate of the economic importance of environmental goods and services in the UK economy[42]. This data has been developed by a consulting firm to deal with the first of these difficulties, which it does by identifying from the bottom-up the supply chains for a wide variety of environmental goods and services. However, while this data has been widely cited – both by advocates for a green economy and by ministers – it does not have the status of official statistics, and is not subject to the same degree of transparency and accountability as official statistics. Businesses and policymakers need a higher level of confidence in such data if it is to play a role in changing our understanding of the green economy.

The ONS has periodically looked into this issue, and in 2010 produced a discussion paper highlighting both the importance of collecting such data and the difficulty of doing so rigorously[43]. The 2010 paper indicated that a follow-up would be published in 2011, reporting on the results of a study looking into the feasibility of establishing ongoing measurement of environmental goods and services. The 2011 paper was never published, and inquiries with ONS indicate that the project was postponed. It is clearly important that ONS be directed to re-launch this process, and develop a coherent approach and indicators for measuring the importance of the environmental goods and services sector to the UK economy .

41 Eurostat 2009. The environmental goods and services sector: a data collection handbook. Eurostat methodologies and workingpapers.
42 BIS 2013. Low carbon and environmental goods and services (LCEGS) report for 2011/2012.
43 Livesey, D. 2010. Measuring the environmental goods and services sector. Economic and Labour Market Review, December 2010. Office for National Statistics.

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2.3 Information needs for markets

Introduction

It is a truism that markets need information in order to work effectively, and ‘perfect information’ is a common assumption in theoretical economic analysis. But, of course, in a complex real world, where the provision of information can be expensive, what matters is not perfect information but complete material information. Investors, businesses and consumers cannot possibly know everything about everything in the markets that concern them, but they should be able to know everything that is known and important in relation to, for example, the risk and return on an investment, the value and

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Principle 3: We will seek appropriate disclosure on ESG issues by the entities in which we invest.

Principle 4: We will promote acceptance and implementation of the Principles within the investment industry.

Principle 5: We will work together to enhance our effectiveness in implementing the Principles.

Principle 6: We will each report on our activities and progress towards implementing the Principles.

In 2012 the PRI had 1190 signatories (including asset owners, investment managers and professional service partners), 156 of which were UK-based.

The role of governments and policy in this area is, first of all, to ensure that the information provided is accurate and not misleading; and secondly that it covers all material, or important, issues, where these issues may be financial or relate to some other accepted moral or social norm. As already noted these norms change over time, and therefore so should the requirements relating to the information that markets should provide.

The power of normative, or moral, information in relation to markets is well established. Attempts

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2.3.1 Information needs for investors

An assessment of an investment proposal generally evaluates seven lines of evidence to determine the value of the asset (the "COD-VERB" framework)[45]

1. An accurate understanding of the cost (how much does it cost to acquire and maintain?)

2. Confirmation of ownership of the asset (is there clear legal title, and what does it cover?)

3. Some disclosure of the importance of the asset (is there a published disclosure of the asset's utility, and is it based on robust foundations?)

4. Ability to confirm the value of the asset (is there a defensible valuation methodology? Are the technical metrics aligned with their financial equivalents?)

5. Evidence of the existence of the asset (is there an accurate audit of the asset's existence, location and particulars? Are control procedures in place to deal with any changes in the asset's composition?)

6. Clear lines of responsibility for the asset (is the management system established, and line of responsibility clear cut?)

7. Are there measurable benefits from the asset (how are these measured? How can they be exploited to increase competitive advantage or shareholder value?)

The investor will be looking for a credible range of opinions and data (quantitative and qualitative), to better assess the nature and vulnerability to risk. Some issues, such as water, readily map across to the seven-point framework outlined above. Others, such as biodiversity and ecosystem services (BES), are more difficult. Until recently, 'mainstream' investors saw green issues as a niche market, or as only relevant to specific sectors. There is growing awareness that resource scarcity and other environmental issues are in fact mainstream.

Some of the information that investors need beyond their in-house analyses will come from third-party research. For example, a 2010 RSPB publication[46] helped investment analysts see the pros and cons, and likely implementation, of taxes, offsets, conservation credits and ecosystem services. Another example is Carbon Tracker, which challenges analysts via paradox, identifying

45 Harris and Mainelli 2001, Information Technology for the Not-for-Profit Sector. ICSA Publishing. pp. 28-29.
46 Comerford, E., Molloy, D. and Morling, P. 2010 Financing Nature In An Age of Austerity, RSPB (Royal Society for the Protection of Birds) http://www.rspb.org.uk/Images/Financingnature_tcm9-262166.pdf

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the carbon assets on corporate balance sheets that will need to remain unburned if the average global temperature increase from global warming is to be kept below 2ºC, as is the current global aspiration. The answer is unsettling, as Carbon Tracker (2011) states: 'Governments and global markets are currently treating as assets, reserves equivalent to nearly 5 times the carbon budget for the next 40 years. The investment consequences of using only 20% of these reserves have not yet been assessed[47].' A third example comes from Bloomberg, whose ESG (environmental, social and governance) data services are growing rapidly in response to investor demands[48].

Of course, depending on political views and levels of scepticism over or confidence in complex and emerging climate science, and the ability of global institutions to limit greenhouse gas emissions, investment analysts may disregard this 20% limit estimate as a triviality. Or they may put it front and centre in analysis of a company's value, treating it as a material risk to fossil fuel companies. What is undeniable is that it is important that the information is available to enable them to make that choice.

Policies for investor information

Beyond the private sector, government can do a number of things to encourage further penetration of the mainstream by resource and environmental issues.

First, there is the issue of investor access to newly available 'big data'. Satellite and remote sensing are increasing enormously the quantity of data that could be available and useful to guide investment. For example, Z/Yen and the Long Finance London Accord community (which involves over 50 financial institutions and thousands of people in finance, and has published nearly 400 reports since 2005) have produced three reports on global data requirements for financial markets in the forestry, water and BES sectors[49]. The type of dialogue that government has with investors could benefit from government understanding of how financial analysts use such data, so that the UK Government could be much more assertive about 'open data' or 'big data' approaches on the environment. Investors also want access to the science data that will help them make decisions, for example Natural Environment Research Council data such as satellite imagery, or regulatory testing of water. There are welcome signs of Research Councils moving in this direction. This would be more effective if such moves were implemented in close conjunction with the investors who want to make use of the data.

47 Carbon Tracker (2011) Unburnable Carbon – Are the World's Financial Markets Carrying A Carbon Bubble?, Carbon Tracker, London. See also Carbon Tracker (2013) Unburnable Carbon 2013: Wasted capital and stranded assets, Carbon Tracker and Grantham Research Institute, London
48 Leinaweaver, J, 2013. Might new financial tools translate ESG data into real-world loss and profit? The Guardian, Monday November 25th 2013.
49 Z/Yen Group 2010 Finance & Forestry: Where's the Data? and Finance & Water: Where's the Data? ; 2011 Finance, Biodiversity & Managed Ecosystems: Where's the Data?

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Secondly, price volatility is one source of uncertainty with which businesses and investors have to cope. All uncertainty adds to business costs. Point estimates of uncertain values obscure, and therefore compound, uncertainty and increase costs. Confidence accounting uses distributions (rather than discrete values) where appropriate in auditing and accounting. With confidence accounting, the end results of audits would be presentations of distributions for major entries in the profit and loss, balance sheet and cash flow statements. The claimed benefits of confidence accounting include a fairer representation of financial results, reduced footnotes, more measurable audit quality and a mitigation of mark-to-market perturbations. Originally sponsored in 2011 by the Association of Chartered Certified Accountants, the Chartered Institute for Securities & Investment, and Long Finance[50], additional support has since come from the Institute of Chartered Accountants in Scotland[51].

Confidence accounting proposes that financial accounts show ranges of values, with a clear and concise explanation of the assumptions used to generate the expected value. This could be a full-blown distribution range, a bit like the Bank of England's inflation 'fan' charts. It could also be some simple downside and upside ranges at, say, the 5% and 95% confidence ranges as assessed by management, who should have the best views on technology and resource recovery prospects. It seems reasonable that as these views constitute a major part of the valuation the inherent uncertainties of management should be shared. This kind of analysis is anyway conducted before committing billions to new exploration projects, so sharing it is not that difficult a step.

The current bias in accounting towards 'conservative values' leads, like any systematic bias, to a misallocation of resources. This distortion can be reduced by incorporating the potential upside in a clear and consistent manner through confidence accounting, the ranges of which should help outside parties to evaluate not only the best estimate of reserve values (instead of the conservatively biased estimate they currently get), but also the views and beliefs of management. Evaluating how and for whom confidence accounting should be introduced is a job that the Financial Reporting Council[52] should undertake as a priority in today's increasingly uncertain world.

Confidence accounting could be particularly appropriate, for example, for natural resource companies, which hold a significant part of their value in physical reserves. Reserve valuation is a combination of art and science. Exploration and production companies, as well as their lenders and investors and potential merger or takeover targets, spend a lot of effort understanding the physical reserves. But they cannot look to the financial accounts for much help: those give a

50 Harris, Mainelli and Onstwedder, 2012. Confidence accounting: a proposal. Chartered Institute for Securities and investment, Long Finance, Association of Certified Chartered Accountants.
51 Onstwedder and Mainelli (2012), 'Buried Treasure' (confidence accounting and natural resource companies), The CA, ICAS + the Institute of Chartered Accountants of Scotland (December 2012), pages 84-85.
52 See http://www.frc.org.uk/Home.aspx

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‘conservative’ value based on guidelines generally set to assure lenders about the minimum amounts that can be extracted using today’s technology and brought to market economically at today’s prices. Yet lenders need to understand the range of possible outcomes, what might go wrong, and what might go well. They, and equity investors, also want to understand how values might change in future, and that means understanding price sensitivities, the range of recoverable amounts not just with current technology but with emerging technologies (for example, the technology associated with shale gas has radically and rapidly affected valuations), and numerous other environmental factors.[53]

This issue of what and how companies should report goes beyond confidence accounting, and includes but is broader than the information needs of investors. Many other issues related to resources and the environment are relevant to corporate reporting, which is the subject of the next section.

2.3.2 Corporate reporting

It is clear that investors are increasingly demanding corporate reporting concerning companies’ exposure to a range of environmental risks. The first reporting on environmental and sustainability issues occurred in 1989. Since then the corporate sustainability report, corporate social

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Resources Institute and World Business Council for Sustainable Development, launched the Corporate Standard, an international accounting tool for measuring and reporting corporate greenhouse gas emissions. This was invaluable in setting a common approach for GHG accounting, which is not yet replicated for other areas of resource use. The UN Global Compact CEO Water Mandate is currently developing a similar tool for water accounting.

In 2003, the first request for specific climate change data on behalf of investor signatories was sent by CDP (Carbon Disclosure Project), covering key areas of governance, strategy and emissions accounting on the basis of the potential risk to their investments that company management of climate change risks and opportunities could pose. With 35 signatories in 2003, the initiative has grown year on year, with 722 institutional investors holding $87 trillion in assets endorsing it in 2013, and also has expanded to cover water (since 2010) and forests (since 2013) (see Box 2-3 for more details).

Box 2-3: CDP

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above, more than 100 sustainability ratings are in operation[56] and sustainability information is integrated into Bloomberg terminals and Google Finance. However, most of the information provided relates to carbon and climate change issues. There is still a big gap between the more established practices of reporting and comparing greenhouse gas emissions data and that related to other important resource issues. As the experience of CDP is showing, this gap may be expected to narrow as these other issues acquire greater materiality.

Impact of corporate reporting

All the indications are that environmental, social and governance (ESG) issues are a growing consideration for businesses and investors: investor signatories to CDP have grown year on year for all programs and reached 771 investors in 2013 for the climate change request; the PRI signatories have also grown year on year, reaching 1190 in 2012, and a study of SRI funds across Europe[57] identifies a growing market for SRI funds in both Europe as a whole and in the UK in particular.

In addition to gaining numbers, investors are beginning to ask for more from companies. For example, CDP's Carbon Action request, with 95 signatories in 2013, asks companies to go beyond disclosure and demonstrate action and 310 investors got involved in the PRI's engagement and shareholder resolution activities in 2012, of which 26% were focused on environmental issues.[58] In addition, there are examples of investors going beyond engagement and using their ultimate power of divestment to drive change – for example, from 2013 UK asset management company CCLA's charity clients intend to divest from developed-world energy, utility, industrial and materials companies in the Global 500 that have not yet disclosed reduction targets.[59]

However, such considerations still influence only a very small part of the overall investment landscape. KPMG estimate that in Europe in 2010 SRI funds accounted for only 2.3% of the total number of funds and 1.6% of the assets under management[60], with the UK the fourth largest market in Europe[61] in terms of number of funds and the third largest in terms of assets under management held in SRI funds. Moreover, the subject matter on which investors are engaging is limited by the availability of information and the maturity of reporting, and in the context of resource efficiency, does not cover the range of issues that are important for future resource sustainability. Finally, peer-to-peer comparability at a data level is hampered by inconsistent

56 SustainAbility, 2010. Rate the Raters Phase 2: Taking Inventory of the Ratings Universe.
57 Eurosif, 2012. European SRI Study 2012.
58 Principles for Responsible Investment, 2012. Annual Report. Available at http://www.unpri.org/viewer/?file=files/Annual%20Report%202012.pdf
59 CDP, 2011. CDP Carbon Action Initiative Summary Report. Available at https://www.cdproject.net/CDPResults/CDP-Carbon-Action-Initiative-Summary-Report-2011.pdf
60 KPMG, 2012. European Responsible Investing Fund Survey. Available at http://www.kpmg.com/LU/en/IssuesAndInsights/Articlespublications/Documents/European-Responsible-Investing-Fund-Survey.pdf
61 The study includes all funds domiciled in Europe, the Cayman Islands and Bermuda.

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operation of any facility (Scope 1), emissions arising from the purchase of electricity, steam, heat

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constraints. Finally, it can become difficult or even impossible to respond to emerging waste management and resource efficiency requirements. As companies have responded to these risks, they have also sought to identify opportunities for cost reductions if resources can be used more efficiently. To gain a better understanding of these risks and opportunities, companies are increasingly asking their supply chain partners to report to them on key environmental aspects.

Producer-to-corporation reporting is an evolution of supplier/purchaser relationships and its chronology is difficult to track. However, the increasing focus on supply chain responsibilities promoted by NGOs, the development of methods and protocols for measuring and reporting supply chain impacts, and the presence of formalised programs to capture supply chain reporting is evident. Although producer-to-corporation reporting is a much more recent phenomenon than that of corporates to investors, it has grown at a much faster rate, due to the learning that is already in place as a result of the trend of corporate-to-investor reporting and the more direct relationship between the purchaser and supplier.

Industry collaborations are much more common in the realm of producer-to-corporate reporting, with key aims of standardising the metrics on which suppliers report to ensure the sustainability of supply chains, and using collective engagement as a way to bring the industries that supply them up to a better standard whilst maintaining a level playing field. These are the forerunners of the producer-to-corporate reporting processes, focused initially on broad sustainability, and developing into more focused initiatives on measuring and reporting, examples of which include the Leather Working Group created in 2005 to develop an environmental stewardship protocol specifically for the leather manufacturing industry, and the global Programme for Responsible Sourcing established by Unilever in partnership with some of its peer companies.

More formalised reporting systems followed, facilitated by NGOs in partnership with companies. CDP's Supply Chain programme sent its first information request to suppliers in 2008, replicating the process for publicly listed companies, but this time using supplier lists from member corporations with the authority being that purchasing organization. Starting with the climate change questionnaire, the programme has now expanded (in 2013) to include water. The Forest Footprint Disclosure (now CDP's forests programme), which is aimed primarily at organizations that rely on commodities that have the potential to bring about deforestation in their supply chains, was founded in 2009. Also in 2009, The Sustainability Consortium began its work looking at measurement and reporting systems for product level data, working with Walmart and others, and the GRI initiated the first phase of the Global Action Network for Transparency in the Supply Chain Program, building capacity among companies in supply chains to measure and report their sustainability performance.

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The role of NGOs is not however limited to facilitating reporting platforms. In the producer-to-corporation reporting arena, more campaigning NGOs have highlighted the reputational ris.

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gauge the extent to which sustainability is a driving factor. Academic literature looking at case studies from Brazil suggests that it is limited[66].

That said, as for corporation-to-investor disclosure, cascading the requirement for measurement throughout the supply chain can support others, often smaller companies, in establishing measurement and therefore management techniques. For example, CDP's supply chain program makes requests for information from selected suppliers of 50 leading companies, including Walmart, Dell, and Unilever, amounting to more than 6,000 companies, and in 2011 Microsoft announced that they would require their suppliers to produce sustainability reports by 2013. This scales up the reporting process significantly in a way that relying on stock exchange listings cannot.

Box 2-4: Promoting sustainable strategies: examples from Unilever and Marks and Spencer

Unilever's Sustainable Living Plan[67] was launched in 2010. It is notable for its prominence in the company's overall business communications, its full value chain approach, and its inclusion of all three pillars of sustainability (environmental, social, economic). It contains three broad aims – improve health and well being, reduce environmental impact and

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Policies for supply chain information

The UK's decision to require data on greenhouse gas emissions in the annual Directors' report is clearly a positive move to facilitate greater levels of reporting. However, there are two main limitations:

- In an attempt to reduce the burden for reporting companies the requirements contained within the Regulation do not specify methodological or boundary approaches and therefore will not address any of the issues already present within voluntary reporting regarding peer-to-peer comparability. This limits the ability of others to use the data to drive change.

- It is focused only on the most established reporting theme – greenhouse gas emissions. Many companies, NGOs and academics are working towards comparable reporting mechanisms for all resources and it will be important to keep pace with these developments and expand the Regulation as necessary to maximise the potential to build a resource-efficient economy.

With good, comparable data that covers the key areas of resource use across the spectrum, it could be expected that investors, purchasers and NGOs will drive action. However, absent such data, this is likely to be patchy and slow. The first policy conclusion that this leads to is that, at the stage of review of the mandatory reporting regulation (due 2015), the requirements should be extended to include supply chain engagement for certain sectors (e.g. those relying on mineral extraction or with agricultural supply chains), and measures to increase the comparability of the data reported should be considered, for example by specifying a standard organizational boundary or specific metrics for emissions intensity (potentially by sector).

A second policy recommendation is that the UK Government should start systematically to apply criteria for its own purchasing and procurement as those of the best private-sector companies , such as Unilever and Marks and Spencer, apply to theirs. It is frankly bizarre that these two companies (and some others) seem more keen to assure the social and environmental integrity of their products than the Government. There should therefore be a special public sector working group, separate from but allied to the Resources and Environment Reporting Council, again working with a range of stakeholders, to build capacity in the UK Government and local councils to understand the wider environmental and resource implications of procurement decisions, and to develop a much more ambitious Green Economy Procurement Strategy with strict criteria for sustainable public procurement, extending and adapting the best private sector practice, that could come to represent a 'gold standard' in procurements. It isa4e shoudil, again p3(d)-.doals t

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Internationally, there is currently a real chance for the UK Government to build on the Prime

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The result from around 2005 was significant action (often competitive action) by businesses – particularly in the US and the UK – to provide increasing amounts of green information. Company strategies, and the information that flowed from them, typically developed by beginning with publication of information on the greenhouse gas emissions and associated environmental impacts of the direct operations of the business (mainly its buildings; its production operations and its transport systems). They then extended over time (but usually in a more piecemeal and selective way) to the upstream impact - e.g. the sourcing of raw materials; voluntary compliance with sustainability initiatives (e.g. sustainable palm oil); and initiatives to conserve water or other resources. And this then might lead to initiatives aimed at empowering the consumer by providing green choices either through their purchasing or through other actions. Some businesses have coordinated these processes into well-presented strategies as noted in Box 2-4.

Examples of attempts to empower 'green consumers' in recent years – involving but not restricted to the provision of information – are many and varied, as shown in Box 2-5.

Box 2-5: Examples of initiatives intended to facilitate green cx 2-5.

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focused on providing information, small incentives and stimulating collective action ('We're all in this together' type initiatives). These sometimes stimulated a short-term response, but there are relatively few examples of significant, sustained behaviour change resulting from information or related initiatives. This innate difficulty has been compounded by customer confusion. Initiatives have on the whole been fragmented, with competition among businesses over claims and ways of communicating information (see Box 2-6 on the experience with 'green tariffs' for electricity). The impetus behind drives to develop a unified approach to carbon labelling has waned (with different systems being developed in different parts of the world and fewer rather than more labels on products in the UK). At a more macro level, it is now hard to perceive much clarity or confidence about where consuming-facing initiatives should focus, how they can have genuine impact and whether indeed the provision of information is the best means of empowering consumers or driving consumer action.

In conclusion, it is clear that the voluntary provision of information by suppliers to consumers, even when this has been independently certified, has at best supported niche markets, and has

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were purchasing. The Green Electricity Marketplace website [71] indicates that only one (Good Energy) of the six small suppliers listed as supplying '100% green electricity' has a certified scheme, while the renewables share of the Big Six suppliers, who all have certified schemes, varies from 3.9-14% [72]. The final irony of this complicated saga is that, due to efforts by the energy regulator, Ofgem, and the Government, to clarify electricity tariffs more generally by reducing the number suppliers can offer, it seems likely that some suppliers will discontinue their 'green tariffs' altogether. Indeed, the GECS website indicates that as of August 2013 five of the eight certified schemes listed are no longer open to new customers [73].

More widespread impact will require the more systematic provision of information across a wider canvas, perhaps through the provision of enhanced environmental information through on-line purchasing, where the scope to provide more information is greater than through physical labelling and where the consumer is arguably more likely to take notice of and be influenced by well-presented information. The impact of this information could be greatly magnified if a well-trusted independent body would endorse 'green better buys' which would have a chance of going viral. Such an approach could be combined with the development of a single, uniform way of communicating the key environmental impact of a product, focusing on a single priority ae Goo[(pur)17.2(chasied wituseon outiltmaemeswarusHowdeiGoe:e)9 -1.)5(Tst0uambinebed hiour a chgees fr)17 w bocusessaricaan thrruandathr

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2.4 Information and policy packages

Some of the clearest evidence of the potential of information to contribute both to resource-saving and reduced environmental impacts comes from experience with labelling. This section contrasts two situations: where labelling as part of a policy package has achieved that potential, and where stand-alone labelling has so far signally failed to do so.

Labelling as part of a policy package

Energy labelling in the European Union was introduced through a Directive in 1992, which was updated in 2010, such that most white goods, and a range of other products, are now covered. An example, of a label for an A-rated washing machine, is shown at Figure 7, showing an A-G rating (with A extended to A+, A++ and A+++ in later versions for some goods to take account of energy efficiency improvements), and other relevant performance information.

As may be seen from Figure 7 the washing machine energy

7 A 7 A

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In the UK these labels had a very limited impact on consumer purchases until this information was combined with other policies, such as the Government Energy Efficiency Commitment (EEC) scheme, which required energy suppliers to install energy-saving equipment in people's homes. A comprehensive evaluation of the scheme (Lees, 2006[74]) from which the rest of the information in this section is taken, was carried out in 2006. Under EEC, suppliers were able to subsidise the installation of more efficient appliances. The energy label on the appliances made this possible, but take up of the more efficient appliances had been slow, as is shown from the figures below.

With regard to cold appliances, Figure 8 shows market shares of sales broken down by energy rating from 1996-97 to the end of September 2005. In 1997, when the energy labels had been out for some years, the shares of sales of A- and B-rated appliances were still very low. In the energy efficiency supplier obligation scheme before EEC, called EESOP, cold appliances down to

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Lees lists a number of factors as having contributed to the growth in sales of A-rated cold appliances, with the following as the 'key ingredients': EU energy labelling; EU Minimum Performance Standards; Energy Saving Trust and Government marketing campaigns; consumer advice from the Energy Efficiency Advice Centres; media coverage on climate change; retail staff training and point of sale material from the Energy Saving Trust; Energy Efficiency Recommended branding and advertising; EESOP and EEC funding for incentives; and the uplift factor in EEC1 to encourage market transformation.

Lees' judgement is that the introduction of European Union energy labelling of white goods was the first important development contributing to this market transformation, providing 'clear and unambiguous differentiation between the energy efficient and other appliances'. Two other important factors were the Minimum Performance Standards legislation introduced by the European Union, which removed from the market the lowest performing products (energy labels E-G in the case of fridge freezers), and the work of EST in promoting Energy Efficiency Recommended[75] products and training retail staff to understand and be able to explain the energy label to customers. However, he also considers that the financial incentives available from the energy suppliers under EEC from 2002 were important in the substantially more rapid transformation of the cold appliance market that can be seen in Figure 8 from that date. Lees also shows that the experience for wet appliances, which were also supported under EEC, was very similar.

Condensing boilers introduce another possible element of policy packages, because, in addition to being supported under EEC from 2002-05 (as were cold and wet appliances), the 2005 Building Regulations passed for England and Wales required condensing boilers to be fitted as the norm. Figure 9 shows the result in terms of market penetration of boiler sales. While it is clear that the growth rate of the market penetration in the EEC period was higher than before, the really dramatic increase occurred after the regulation in 2005.

However, Lees also concludes that although the Building Regulations played the major part in transforming the condensing boiler market, without the earlier availability of financial incentives through EEC, and work by the Energy Saving Trust and others in building confidence and expertise with the new boilers, Government might not have had the confidence to regulate such a sharp increase in their rate of uptake. In such situations 'It requires a combination of awareness, training and the presence of financial incentives through EEC to prime the market such that the Government can have confidence in legislating for energy efficient solutions being the norm.'

75 Now 'Energy Saving Recommended'.

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Figure 9: Penetration of condensing boilers as a percentage of the total boiler market from 1998/9 to the end of 2005. Source: Lees 2006, Figure 5.7, p.38

Stand-alone labelling

A very different, and much less positive, story is apparent regarding the Energy Performance Certificates (EPC) that arise from the EU Energy Performance in Buildings Directive (EPBD). The EPBD was adopted in December 2002 and is the main legislative instrument affecting energy use and efficiency in the buildings sector in the EU. It explicitly seeks to tap the potential for energy savings in the buildings sector, which is often viewed as the sector with the highest cost-effective energy savings potential. The Directive is designed to promote the energy performance of buildings through the introduction of a framework for an integrated methodology for measuring energy performance; the application of minimum energy performance standards in new buildings and certain renovated buildings, and regular updating of these; energy certification for and advice

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addition to responses to prices and regulations. Having said that, it is also clear that price factors have an impact on behaviour, so that taxation and other fiscal policies can play a significant role in encouraging greener behaviours.

This recognition of multiple behavioural motivations finds expression in the latest generation of electricity demand side management models, looking forward to the greater provision of information through smart meters. Such models incorporate not only financial incentives and technological innovation but also customer attitudes, awareness and engagement. There is substantial commercial value in the potential for efficiency gains from smart meters, which could be shared between suppliers and consumers, but attention will need to be paid to consumer attitudes, influenced by social norms, for this to be realised. Energy suppliers recognise the role of attitudes and social norms and recognise that changing consumer behaviour is not only about lower energy bills but also about emphasising health benefits, the virtues of being green, impacts on children, and about doing better than your neighbours – issues that recur below.

With energy conservation too, psychologists suggest that policy-makers need to broaden their approaches. Consumer responses to information and money are more complex than standard economic analysis suggests and other motivations also drive people towards saving energy. For example, people may choose to reduce boiler temperatures, rather than engage in the complex analysis required to invest in insulation. Energy conservation decisions reflect an interaction of economic and psychological factors and barriers, the latter including risk and uncertainty, constraints on learning, social norms, disempowerment and procrastination, and fashions and social pressure. Providing more information, whether via smart metering technologies, labelling or certificates, can increase awareness and transparency of energy use, but information by itself is rarely effective, and such information as is provided needs to be clear, comparable and standardised, if consumers are to compare different options.

Analysis using behavioural economics has now generated powerful insights into a number of key drivers of human behaviour, including those related to energy and the environment, such as loss aversion, framing effects, reference points, heuristics and cognitive bias; time and discounting, planning and habits, goals and feedback; social learning and influences (on firms as well as individuals); social preferences, for example relating to perceived fairness; and emotions, happiness and wellbeing. All these issues have implications for policy. Balancing the roles played by traditional economic policy-making versus socio-psychological factors, a crucial issue is the extent to which price factors versus non-price factors play a role. If the former, standard economics with adjustments for externalities, asymmetric information and principal agent problems will be a good analytical approach; but if non-price factors have significant impacts then the psychology of decision-making needs to be addressed. In this, insights from behavioural economics such as those above need to be given weight.

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The same issues are also relevant to regulators. For example, the issue of switching energy supplier, to which the energy regulator Ofgem has given much attention, clearly involves much more than just giving people information about the cheapest deal. Ofgem analysis of consumer biases and their impacts on energy consumers has revealed issues of limited cognitive capacity, status quo bias, loss aversion and time inconsistency[79]. Insights from behavioural economics can be useful in enabling smart metering technology to be installed which supports the effective use of information in the effective planning of energy consumption. Effective planning is constrained by bounded rationality – it is a complex task to manage energy demand even if time-varying tariffs are available. If effectively delivered, smart metering technologies could enable people to adapt to real-time pricing and other tariffs which match supply and demand conditions more effectively. The technologies could also incorporate normative information, for example to harness social influences on energy consumption, and could provide immediate feedback to energy users enabling them to develop new energy-efficient habits. Policy makers must not allow the projected rapid pace of smart meter rollouts to jeopardise the achievement of these benefits.

However, the potency of insights from behavioural economics should not be oversold, and substantial changes in behaviour are likely to require measures deriving from such insights to be combined with other policy tools. Fortunately, social and behavioural science research shows that norms, social networks and social influence and attention to convenience and design will work alongside financial incentives and better information. So policies embedding behavioural insights should complement, not substitute for other economic interventions.

2.6 Conclusions on information

This section has set out who needs to know what about the environment and resource flows: policy makers need material flow and natural capital accounts to understand overall material flows and their environmental impacts and in order to be able to safeguard, maintain and facilitate the provision of non-market ecosystem goods and services; and investors, producers and consumers need a range of enhanced information for markets to work effectively. Information can make a powerful contribution to behaviour change that supports a green economy, but it is rare that this happens through the provision of information alone. Information may also be expected to provide a key motivation and underpinning for innovation for a green economy, which is the subject of the next section.

79 Ofgem 2011 What can behavioural economics say about GB energy consumers?, March, https://www.ofgem.gov.uk/ofgem-publications/39711/behaviouraleconomicsgbenergy.pdf

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Figure 10 summarises the various issues discussed in relation to information provision and disclosure for national government, investors and corporations:

	Government	Investors	Corporations
Conventional Information Metrics	System of national accounts; gross domestic product, current account, net exports	COD-VERB framework for investment decisions; investor analysis and reports	Annual report: standard financial metrics and reporting
Environmental and resource (E&R) risk to actors	Climate shocks increase health costs and damage infrastructure; agriculture variability; resource shortages	Damage to, or mispricing of assets in investment portfolios; increasingly large insurance payouts	Increasing resource and waste costs; reputational damage from supply chains
Information required for managing own E&R risk	Comprehensive view of the material basis of the economy, similar to economic national accounts; E&R boundaries and bottlenecks	Investment in different sectors that contribute to environmental damage; E&R 'Big Data'	Own E&R requirements and impacts; supply chain data on key environmental, social and governance (ESG) issues issues; benchmark ESG relating to competitors
Current E&R information disclosure	Environmental accounts; carbon accounting and budgeting	According to Principles for Responsible Investment; ad-hoc research	CSR and sustainability reports; green claims on products; returns to CDP
Proposed E&R information disclosure	Construction by ONS of natural capital and material flow accounts, linked to UK NEA information; monitor resource prices; development of consumption-based accounting	Integration of environmental data into COD-VERB framework; use confidence accounting that provides a risk assessment of asset values	Work with RERC to establish a comprehensive, standardised E&R reporting system, apply the system to supply chains, contribute to SDGs through Global Compact

Figure 10: Proposed changes in the information infrastructure to support a green economy

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Summary of recommendations on information

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and deployment of new technologies, often with some urgency[82]. An additional view highlights the role that green innovation policy can play, not only in ensuring that targets are met at minimum cost, but also in fostering growth. Technological change has been identified as a key driver of economic growth since path-breaking work of Robert Solow in the 1950s[83], and economists continue to understand innovation as a driving force for growth[84].

Our main message is that Government can and should play a strategic role not only in strengthening the UK innovation system but in orienting it towards 'eco-innovation' – the development of new products, business models, processes and ideas that reduce environmental harm. In both the short and long term, setting a course for a green economy can catalyse innovation with benefits for both the environment and the economy. As with other areas of the green economy, the message is the same: the whole is greater than the sum of its parts, and driving an eco-innovation agenda is not just about implementing specific policy instruments, but about a catalytic role for government in setting a strategic agenda and direction for economic development.

3.1 Core propositions for innovation policy for a green economy

The following discussion is rooted in four core propositions which underpin our argument for innovation policy for a green economy.

1. Innovation is critical for both economic prosperity and environmental sustainability

As already noted, economists have long argued that innovation is critical for long-term growth and prosperity. Successive waves of economic transformation and growth have been preceded by major innovations: steam power and the railway, electrification, mass production, and most recently, the ICT revolution. The point here is that innovation policy is also growth policy[85].

Nevertheless a number of commentators have highlighted that the UK's short, medium and long-term growth prospects could be undermined with stagnant or falling investments in innovation

82 Stern 2007. The Economics of Climate Change. HM Government, TSO, London.
83 See, e.g. Solow 1956. A Contribution to the Theory of Economic Growth. Quarterly Journal of Economics. Vol. 70.
84 See, e.g, the work of Paul Romer, Philippe Aghion and Peter Howitt.
85 Tassey 2012, Beyond the Business Cycle: the need for a technology-based growth strategy. National Institute of Standards and Technology; Atkinson and Ezell 2012, Innovation Economics. Yale University Press

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2. The direction and rate of technological change are not predetermined: societies, through a range of institutions, make choices about which technological paths to develop

For every set of technologies and areas of science we pursue and develop, other possible development paths are abandoned. This means that there is not a single optimal path

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and choices in R&D funding priorities, through government procurement choices, and through the entire structure of regulation throughout the economy.

Recent years have seen a shift in economists' and policymakers' thinking about why and how government should be involved in the innovation process. In traditional approaches, the basic rationale for a public policy role in innovation was centred on market failures (particularly the under-supply of R&D arising from knowledge spillovers)[90]. More recent approaches see innovation as arising from a complex system of interacting firms, public bodies, institutions, markets and technological opportunities: an 'innovation system'[91] in which government is an irreplaceable player. While arguments about market failures for innovation are important, they do not provide a sufficient account of the complex relationship between public policy and innovation, and the ways in which policymakers can and should support innovation[92].

Rather than focusing on 'fixing' the problems left by an otherwise effective market mechanism, innovation system perspectives understand the role of government as broader, with government playing an important role in shaping the incentives, structures and rules through which innovation takes place. Government investments in R&D are often critical in exploring innovation trajectories that would otherwise be too risky and expensive for the private sector.

The point here is that innovation policy is not so much a choice between 'intervening' or not. Indeed, this language of 'intervention' presumes that government has to justify its presence in innovation activity, that it is somehow an interloper. This is not a good description of how innovation works in a modern economy[93]. Rather than worrying about the rationale for and mode of 'intervention', the challenge of innovation policy is to understand how government can participate in ways that create a dynamic and vibrant innovation system that meets our social and economic aspirations.

4. An eco-innovation strategy is necessary and it is timely

The fourth core proposition is that we are at a decisive moment, both because the ICT revolution has enabled fundamental change in economic systems, and because of the urgency of environmental problems. The ICT revolution has created the potential for transformations in our economic system and the way it interacts with the natural environment – and ICTs have created new ways of conducting innovation itself. Economic historians have identified ICTs as the latest in

90 Popp 2010. Innovation and Climate Policy. Annual Review of Resource Economics 2(1): 275-298.
91 Lundvall et al 2002, National systems of production, innovation and competence building. Research Policy Vol. 31; Perez (2010) Technological revolutions and financial capital: the dynamics of bubbles and golden ages
92 NESTA, 2012, Plan I: the case for innovation-led growth.
93 Lundvall, Johnson, et al. (2002). 'National systems of production, innovation and competence building.' Research Policy 31(2): 213-231; Malerba, F. (2002). 'Sectoral systems of innovation and production.' Research Policy 31(2): 247-264; Mazzucato 2013, The entrepreneurial state, Anthem Press

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a series of fundamental technological revolutions that have driven great surges of economic development, much like steam and electricity in the past[94]. Just like steam and electricity, ICTs are a 'General Purpose Technology' that have such pervasive impact that they enable transformations in all sectors[95]. ICTs also create the potential for radical greening of the economy through smarter systems, but this revolution needs direction if these opportunities are to be realised[96]. The promise of ICT is the possibility of shifting the emphasis of productivity increases from mainly labour-saving to resource-saving. These kinds of savings are particularly important as prices of energy, materials and water tend to rise with the pressures of global demand. As the economic potential of the ICT revolution is now unfolding, it is essential that this opportunity is seized: ICTs offer a fundamental enabling technology for a greener economy, but this will only be achieved if governments direct the unfolding revolution through intelligent public policy.

At the same time, the urgency of dealing with environmental problems has become ever more acute. This means both that it is important to accelerate the development and deployment of clean technologies; it also means that other countries too are both increasingly developing and deploying clean technologies. There are plenty of opportunities to capture export markets, and these are likely to grow. Nevertheless the UK could fail to establish a comparative advantage if it falters in developing a strategic innovation policy in these clean industries now. The moment of opportunity will pass, especially as other countries such as Germany and Japan are getting involved with the next wave of clean technological innovations.

Those four propositions make the case for innovation to be at the core of a green economy strategy. As noted above, government already makes choices – not always consciously – that shape the direction of our innovative activities. What is increasingly clear is that governments need to make choices that are consistent with long-term social goals, including the need for environmental quality, resource security and climate stability. The increasing acceptance that a simple market-failure model of innovation is insufficient has created a well-recognised need for governments to take a more active approach to innovation and industrial strategy.

Transforming our economy through eco-innovation will not always be easy. The language of innovation conjures an image of dynamic entrepreneurship and rapid change. But much innovation keeps within existing paradigms and trajectories. Re-orienting our economy towards more sustainable ways of doing things will be a challenging process that takes time and confronts many obstacles.

94 Perez, C. (2002). Technological revolutions and financial capital: The dynamics of bubbles and golden ages. Edward Elgar Publishing.
95 Bresnahan and Trajtenberg 1995. General purpose technologies: 'Engines of growth'? Journal of Econometrics 65: 83-108
96 Røpke, I. (2012). The unsustainable directionality of innovation – The example of the broadband transition. Research Policy 41(9): 1631-1642.

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3.2 The context for green UK innovation policy: the return of UK industrial policy

The 'innovation systems' view – in which market failures are recognised to be an important but limited guide for policy action – has become widely accepted in governments around the world, including in the UK[97]. At the same time, governments have shown increasing interest in various forms of industrial policy, particularly since the financial crisis[98]. Debates about sector and technology-specific support in the UK were for many years weighed down by the UK's particular historical experiences and the spectre of failed industrial policy. For many, targeted intervention in specific technologies or industries was seen as a doomed attempt at 'picking winners', which in turn conjured images of failed past national champion projects (such as Concorde, the AGR reactors, and British Leyland, to name a few). These historical images are based on a model of industrial policy that focused on supporting particular firms or particular technological designs that may be more aptly described as picking losers, or even losers succeeding in picking a soft-touch government.

However, perceptions have changed. It is now more widely recognised that intelligent sector-specific or mission-driven policies are not inevitable recipes for 'government failure'[99]. This has arisen both because of the recognition that 'getting out of the way' is not good innovation policy (because of the systemic nature of innovation discussed above), and secondly because it is increasingly recognised that government support has been an important factor in the success of many leading industries and businesses. The UK's strengths in pharmaceuticals and aerospace are in part a result of decades of policy support and research investment. And the demand from business for this kind of approach is clear. In the run-up to Budget 2013, the CBI argued that Government needs to 'deliver a shared vision for an industrial strategy that champions key sectors and protects investment in R&D and innovation'[100].

Many advocates of industrial policy justify such an approach from the basis of innovation systems perspectives. However, even within more traditional neo-classical views of innovation policy, justifications for industrial policy can be identified, in particular with relation to with market failures present in infant industries (especially related to appropriability) and the potential for policy to facilitate industries from benefiting from the spill-over benefits generated in spatial agglomerations of firms, or 'clusters'[101].

Modern adherents of industrial policy recognise the failures of previous models. In particular, it is recognised that industrial policy: should be targeted not at specific 'champion' firms, but at sectors

97 BIS 2011. Research and innovation strategy for growth. HM Government.
98 Warwick, K. 2013. Beyond Industrial Policy. OECD.
99 Mazzucato 2011. The Entrepreneurial State. Demos; Gross et al 2012, On picking winners: the need for targeted support for re

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Many of the weaknesses of previous innovation strategies have been recognised, but a number of problems remain. There are several basic elements of the UK's innovation system that remain barriers to innovation in general, and to green innovation in particular, which we discuss below.

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hotly debated, with empirical evidence showing that the evidence for additionality of R&D tax credits is inconclusive[115]. The patent box in particular has been received by many innovation scholars with considerable scepticism[116], and is seen as a costly subsidy (with an annual value of around £1bn) that is unlikely to have a large impact on R&D activity in the UK[117]. While Government has provided a range of support mechanisms, NESTA has noted that many of these schemes are short-term or one-off, and they are fragmented and relatively small in volume[118]. While the BBB will pull together some of these into a coherent whole, the overall level of funding is still too low.

At least part of this apparent weakness in UK innovation is a result of the structure of the UK economy, and the type of innovation activity that is captured by traditional measures such as BERD and patents. BIS analysis shows that, when corrected for industrial structure, UK BERD intensity is higher than that in Germany – though still lower than the US, Japan and France[119]. The UK has large business services, finance and creative industries, whose innovative activities are not captured by traditional metrics. When intangible investments in innovation are considered – a much broader measure of investments in innovation than R&D – the UK picture looks rather better. Even when intangibles are included however, the flow of finance into innovation is disappointing: despite UK firms holding increasing cash surpluses before the crisis, investment in innovation did not rise (see Figure 12)[120].

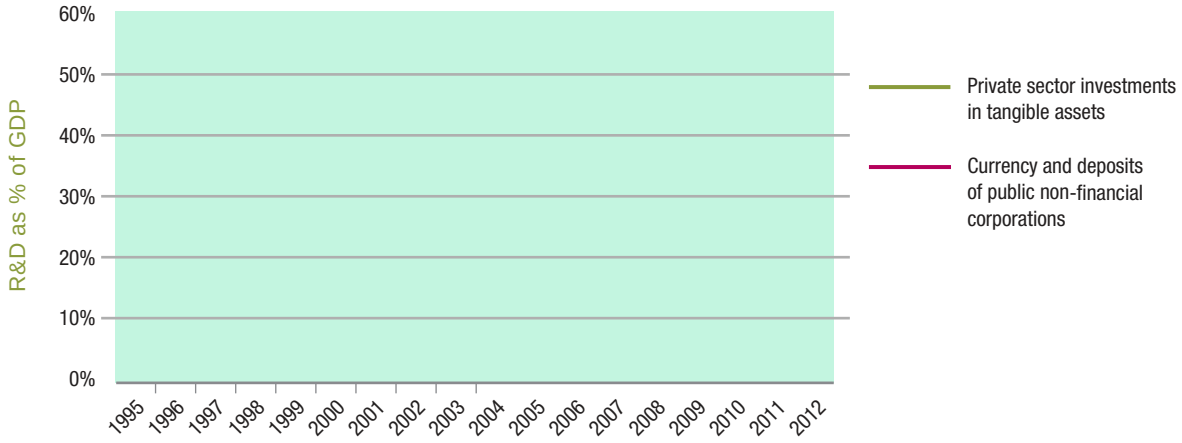

Figure 12: Estimates of UK corporate cash and investments in tangible assets (including R&D) as a percentage of GDP. Source: Levy and Brinkley 2013, Big Innovation Centre.

115 Lentile, D. and J. Mairesse (2009). 'A policy to boost R&D: Does the R&D tax credit work?' EIB Papers 14(1): 144-169.
116 Levy and O'Brien 2013, Will the patent box boost the UK innovation system? Big Innovation Centre.
117 Griffith et al, 2010. Corporate taxes and intellectual property: simulating the effect of patent boxes. IFS Briefing Note 112, Institute for Fiscal Studies.
118 NESTA, 2012, Plan I: the case for innovation-led growth.
119 BIS Annual Innovation Report 2012.
120 Levy and Brinkley 2013, A manifesto for innovation and growth. Big Innovation Centre.

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However, concerns about levels of finance flowing into innovation are not only a problem of the supply of finance. The UK's performance in stimulating venture capital is, for example, very good compared to many competitors, particularly in core green economy areas such as clean energy (Figure 12). Rather, part of the problem is that much of the finance available is of the wrong type: it is not 'patient', seeking to invest in long-term value; rather it is impatient, focused on short-term returns. Furthermore, various scholars[121] have suggested that the UK has a problem of demand for innovation finance as well as a problem of supply. Not enough entrepreneurial firms are seeking finance to invest in new products, services and business models, often because of weak capabilities, skills, or lack of confidence in emerging opportunities. These are not problems that can be solved by providing further tax incentives for investments in R&D, or providing a flexible and welcoming tax environment for venture capital through low capital gains taxes. They require restructuring of the financial and institutional support of the innovation system.

Secondly, relative weakness of support for regional strengths : many of the most obvious national and international success stories in innovation arise from regions that have built-up a cluster of expertise in a particular sector or field of science and technology. A number of countries have attempted to pursue this as a strategy by developing 'cluster policies', with mixed success. A key lesson from such experiences is that establishing successful clusters takes time and dedicated effort over many years – and that it is typically not best undertaken by central government. It is unfortunate therefore that the UK's innovation support system is highly centralised, with a great deal of decision-making based in Whitehall. This has become more acute since the abolition of the Regional Development Agencies, which provided a vehicle for decentralised funding dedicated to innovation. There seems to be a strong case for enhancing the ability of LEPS to drive innovation, in particular by providing the Regional Growth Fund with an innovation funding mechanism[122].

Thirdly, absence of vision . A wide variety of stakeholders have complained that the innovation and industrial strategies articulated by BIS are not aligned under a broad strategic vision of future UK prosperity[123]. This is particularly true in the case of low-carbon technologies, an area in which Government's recent failure of nerve has perhaps fatally damaged investor (and innovator) confidence in the Government's commitment to low-carbon energy.

Fourthly, supporting institutions . The Hauser Review identified the UK's lack of publicly-funded institutions with sufficient critical mass to act as centres underpinning innovation excellence in a given field. The establishment of strategic Catapult Centres in response to this lack is a promising

121 Mazzucato 2013, The Entrepreneurial State; Tredgett and Coad 2013. The shaky start of the UK Small Business Research Initiative (SBRI) in comparison to the US Small Business Innovation Research Programme (SBIR). SSRN.
122 See also Andersen et al 2011, Making the UK a Global Innovation Hub. Big Innovation Centre 2011.
123 House of Commons Science and Technology Committee, 2013, Bridging the valley of death; Eighth report of session 2012-2013; CBI 2012, Playing our strongest hand: maximising the UK's industrial opportunities.

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development, though the levels of funding and support overall are less ambitious than might be hoped[124].

In addition to these major issues, there are other important areas of concern, including skills, immigration, and the intellectual property system[125]. These weaknesses in the UK innovation system still need to be addressed. But beyond this, if growth is to be green, the strategy must be adapted into an 'eco-innovation strategy' that embeds aspirations for a green economy within innovation and industrial policy.

3.3 What innovation is required for a green economy?

Innovation for a green economy requires innovation across all sectors. As climate change impacts and resource limits increasingly bite, and the urgency of emissions reductions intensifies, those firms and countries that have developed more efficient production processes, goods and services will prosper. Green innovation is not only about those sectors typically labelled as 'green' or 'cleantech', like renewable energy. The view of the UCL GEPC is much broader, encompassing a wide diversity of technical, organisational and business innovations (see Box 3-2).

Box 3-2: Innovation in business models: Philips pay-per-lux

Innovation is not just about technology. New business models – like car-sharing – are important sources of innovation-driven growth, and can often have important environmental benefits. The ICT era presents a new set of opportunities for innovative business models, with the availability of real-time monitoring and feedback, geo-location, micro-payment and tracking creating opportunities for the provision of new and more efficient services.

Philips offer a strong example of how innovative business models can go hand-in-hand with innovative environmental technologies. Advanced LED lighting systems can provide high quality lighting at a lower life-cycle cost compared to halogen and compact fluorescent lighting – with much higher efficiency. Yet the upfront cost is higher, and as

124 Andersen and Le Blanc, 2013. Catapult to success: be ambitious, bold and enterprising. Big Innovation Centre
125 See, for example, the Hargreaves Review

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with so many energy efficiency technologies, a strongly positive net present value does not always translate into strong sales. To overcome this problem, Philips have offered a model in which they sell a lighting service, measured in the units of light that customers require. Rather than sell light-bulbs, they manage the lighting services, and this has enabled them to roll-out their LED technologies. The 'pay-per-lux' model is a classic case in which innovation in both technology and business model enable a win-win for Philips and their customers.

Policymakers have tended not to address support for innovation in business models directly. A recent review of attempts to support innovative business models shows a rather limited range of initiatives[126]. One of the problems is that the agencies tasked with supporting innovation tend to be dominated by a technology focus, and the UK's innovation agency – the Technology Strategy Board (TSB) – is no exception. The GEPC recommends that the TSB should consider developing a small fund for proof-of-concept or feasibility studies for innovative business models, particularly targeting energy and resource efficiency.

Despite the economy-wide focus required, it is clear that achieving a green economy requires the development of core technologies, especially low-carbon energy and transport technologies. Energy system modelling work from UCL shows that it is much more expensive to meet climate change targets without key technologies such as wind, carbon capture and storage, and either battery electric or fuel cell vehicles[127]. Many of these technologies require dedicated support, because of the innovation characteristics of the energy sector, the risk profile of the technologies, and capital intensiveness of innovation and development activities.

Scholars have highlighted that capital-intensive, long-term and risky forms of technology are

quadrant, and even here tends to operate at the lower end of technology risk and where early exit opportunities are possible (which is often not the case for clean energy). It is the top right quadrant of the figure that most requires targeted state support, and it is here where the state has often shown leadership in the past[129].

Figure 13: Typology of clean energy innovation b 0 10 56.6925 17.2(5 608pn9 s1t)Tj 7.2 0 0 7.2 2h ofte88 .568630itunpro l

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However, the matrix developed by Ghosh and Nanda misses a further and critically important dimension for green innovation support. The potential for a technology to result in radically improved environmental performance is ignored. This is somewhat correlated with technology risk, but a key part of the risk profile of such opportunities is not simple 'technology risk', but includes substantial policy and 'socio-technical' risk.

Policy risk exists because the returns to investment in green technology depend on public policy action to reflect environmental externalities in prices. Socio-technical risk is a product of the phenomenon of lock-in and path dependency. Most innovation takes place along well-established trajectories, making incremental improvements to existing products and services. Occasionally radical new approaches emerge: from sail to steam; from horse and cart to motorcar; from letters to email.

Responding to climate change and other environmental problems is likely to require these kinds of radical transitions to wholly new ways of doing things[130]. It is this kind of radical innovation that begets new industries and the economic opportunities that come alongside them. Resource efficiency, for example, may require new approaches to supply-chain management and manufacturing, enabling the re-manufacturing and repair of products, requiring completely new ways of organising industrial production. Path-breaking technologies that create the opportunities for radically more sustainable systems face barriers considerably higher than simple technology risk and high capital intensity. It is here that the state has a particularly important role in shaping the institutional context required for radical new green technologies to emerge. Our consideration of the innovation needs for a green economy therefore encompasses three elements:

1. The need for the innovation system overall to respond to the needs of a green economy, by enabling green innovation in all sectors and technology fields .

2. The need for the UK to capture value in developing core green technologies , such as renewables.

3. The need for the innovation system to facilitate the emergence of transformational green innovations that cannot be foreseen but that could ultimately make profound differences to the economy.

130 Kemp, R., J. Schot, et al. (1998). 'Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management.' Technology Analysis & Strategic Management 10(2): 175-195

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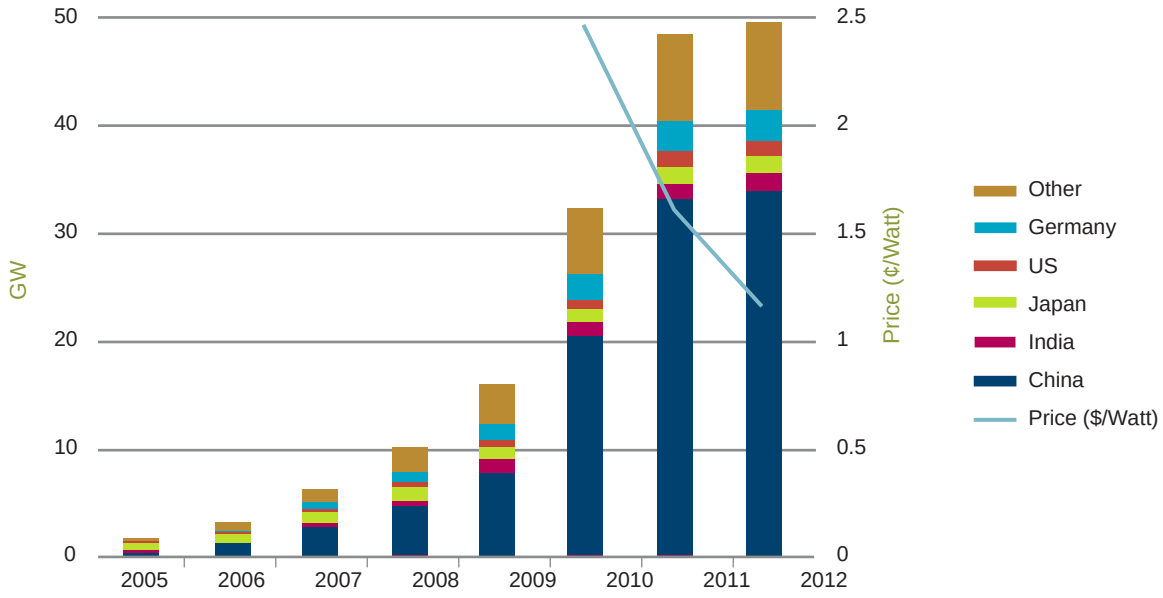

Figure 14: Crystalline silicon PV module manufacturing capacity total, GW/year.
Source: Bloomberg New Energy

3.4.1 Core green technologies and innovation leadership

Markets for core green technologies are growing fast and are becoming more globally competitive. The most prominent example is in clean energy, where investments increased more than five-fold from 2004 to reach $238 billion by 2012[137]. Many countries are seeking to gain significant comparative advantage in core green technologies, establishing world-leading innovation hubs such as that for wind energy technologies in Denmark. Fast growing markets provide growth opportunities, yet the market for green technology is also increasingly competitive. As China, India and other emerging economies with low manufacturing costs enter

137 BNEF(2013). Global Trends in Clean Energy Investment: Fact Pack as at Q2.2013. (London: Bloomberg New Energy Finance): http://about.bnef.com/fact-packs/global-trends-in-clean-energy-investment-q2-2013-fact-pack/

clean energy markets, it is legitimate to question the rationale for the UK to support the development of such sectors. There may be a concern that attempts to support domestic markets for renewable energy simply result in the transfer of manufacturing jobs to China. The key question is how the UK can capture value in these – and other – growing markets for core green economy innovations.

Importantly, there is a critical moment in the development of a technology area in which the opportunity to establish leadership is greatest – the formative phase of technological development that occurs just as the market is becoming established[138]. Countries that are successful in establishing and maintaining innovation leadership can continue to capture large shares of the value of such technologies, even when manufacturing takes place overseas. A great deal has been made of China's relative success in manufacturing solar and wind technologies, with many US commentators bemoaning the fact that China appears to be 'winning' the clean energy race. However, the statistics tell a different story. Despite China's lead in wind and PV manufacturing, exports of high-value added technologies in the solar PV, wind and energy smart technologies allowed the US to have a net trade surplus of over $1.6 billion against China for products in the same sector in 2011[139]. While China has developed comparative advantage in assembly and high-volume manufacturing of final products, the US produces high-technology components across a wide range of clean energy technologies. This pattern echoes wider findings by the OECD on global value chains, which illustrates that the high-value stages in the value chain are often those most associated with knowledge-intensive activities (see Figure 15; also note that this is not true for all sectors).

138 Livesey 2012, cited in Warwick, 2013. Beyond Industrial Policy,.
139 Pew(2012). 'Advantage America: The U.S-China Clean Energy Technology Trade Relationship in 2011.' (Washington D.C: Pew Charitable Trusts).

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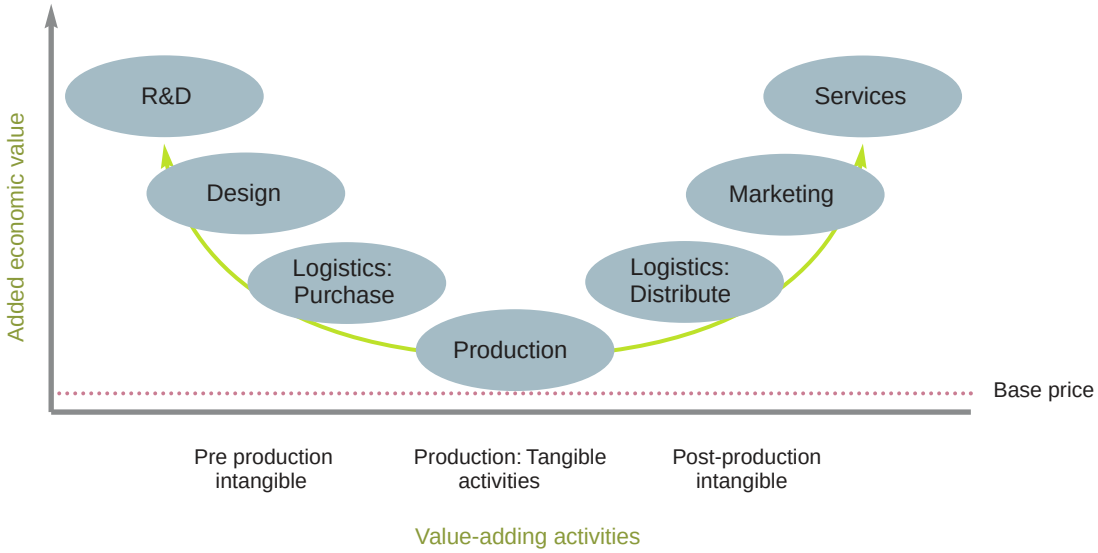

Figure 15: ‘Smile Curve’ of value-added in global supply chain. Source: OECD.

Economies that seek to appropriate the highest returns to investments in green technologies need to focus on those industrial activities that generate the highest value-added returns. Thus economies that are successful in innovation for green technologies retain the highest value-added, even when they lose out to other countries for mass manufacturing.

The difficulty lies in capturing the value of the R&D and design stages. There tend to be strong ‘first-achiever’ (if not always first mover) advantages in R&D strengths in particular industries. Particular places become hubs for key technologies – often known as ‘clusters’– and these tend to be very durable. Silicon Valley is of course the classic example, but the phenomenon is widespread. The agglomeration externalities within ‘innovation hubs’ or ‘clusters’ for particular core technologies mean that skills, tacit knowledge and expertise, supportive financial institutions and regulatory frameworks become difficult to replicate. The spill-overs between companies in a cluster are substantial, and in today’s globalized economy, clusters need to be networked into global supply chains.

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In short, there are opportunities to capture the highest value-added stages through early innovation efforts at the formative phases of core green technologies, since the successful economies which capture a position as a leading innovation hub for a core technology are likely to continue to reap high value-added returns as the sector develops. The nature of global competition for innovation is that once an economy has achieved a strong position of leadership during the market expansion phase, it is difficult for others to catch up (see Figure 16).

Emerging economies have the comparative advantage in high-volume manufacturing, particularly for more mature clean energy technologies such as crystalline solar PV and onshore wind turbines. Once green technologies mature, the knowledge becomes codified and more easily transferable from early innovation economies to places with comparative advantage in manufacturing.

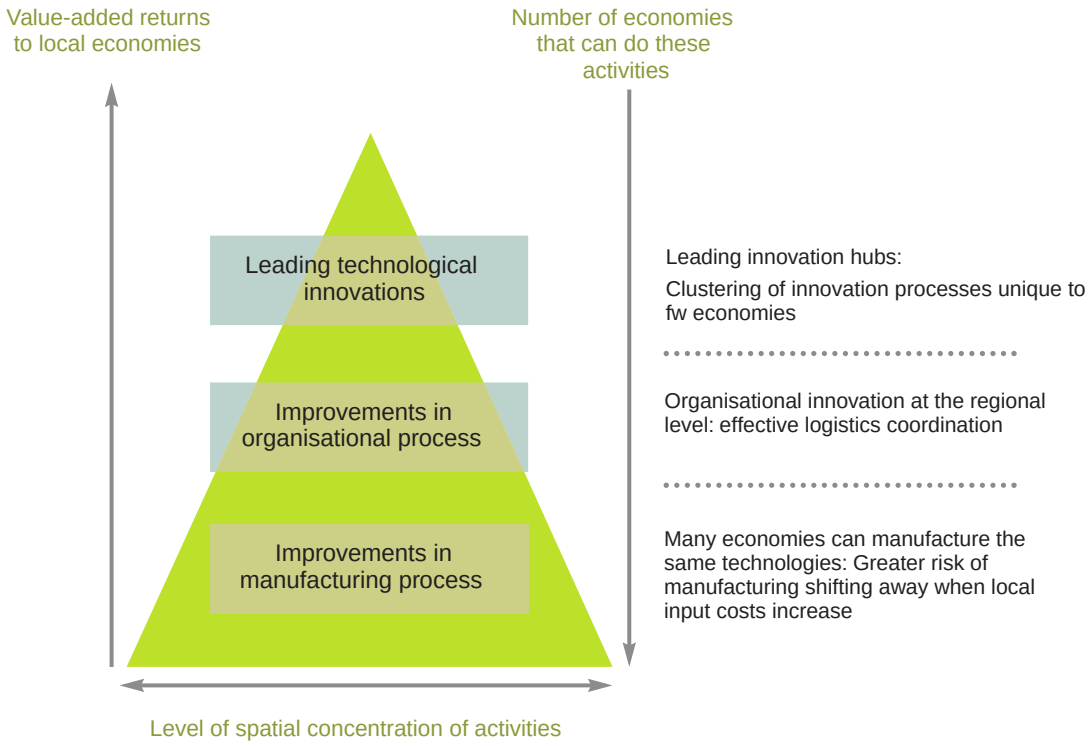

Figure 16: Comparing value-added returns to local economies based on innovation versus manufacturing. Source: UCL GEPC.

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3.5.1 Core green innovation markets

Low-carbon energy is a core green innovation arena, and has been subject to the greatest levels of scrutiny. A number of organisations have developed various indices of low-carbon innovation performance, and have typically found that the UK has some key areas of strength, but is not an overall leader.

Innovation inputs for key green economy sectors are low. Analysis for the UCL GEPC noted earlier showed that the UK has seen relatively low and declining levels of investment in R&D as a proportion of GDP. This pattern of low R&D spending is even more true for various sectors of importance for the green economy. The Committee on Climate Change highlighted in 2007 that the UK still had much lower levels of publicly funded energy R&D, as a proportion of GDP, than most competitors. Despite a sustained increase in funding, this remains the case (see Figure 18). Similarly, the 2009 Cave Review[141] found that investment in R&D by water companies in England and Wales had declined substantially since the 1990s, both in absolute terms and relative to competitor countries. The Council for Science and Technology highlighted the poor innovation performance of the water sector in England and Wales in 2009, a point echoed in June 2013 by the House of Commons Science and Technology Committee[142].

Figure 18: Public funding for energy R&D as a proportion of GDP. Source: IEA

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Yet as discussed earlier, the problem is not solely one of 'lack' of finance. On a per capita or per GDP basis, the UK is a strong performer in terms of venture capital into clean energy technologies, second only to the US among major competitors (see Figure 18). Yet we lag behind many of these countries in terms of developing successful firms and innovations in the clean energy sector. The UK has been successful in generating a venture capital system for clean energy technologies (see Figure 19) – but has been less successful in enabling more forward-looking, long-term 'patient' finance, with lower discount rates, which is increasingly argued to be essential for the development of an industry[143].

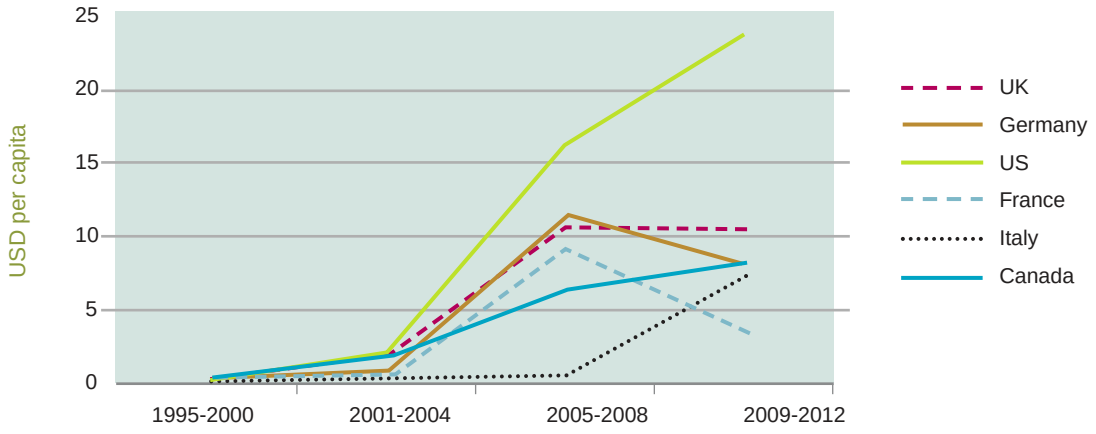

Figure 19: Average annual per capita venture capital investment in clean energy technologies in the UK and major competitors. Source: BNEF and World Bank.

Detailed analysis demonstrates clear areas in which the UK can expect to develop strong areas of advantage. Analysis for the Committee on Climate Change[144] assessed the key areas of UK innovation advantage in low-carbon technologies. In doing so, the analysis suggested that:

- The UK has lost ground over the past three decades in terms of innovation in clean energy technologies (looking at the period from 1980-2007). This is not necessarily because the UK is decreasing the amount of innovation activity, but because other economies (e.g. South Korea) are increasing their efforts and concentration in this area.

143 Hopkins and Lazonick 2013. Soaking up the sun and blowing in the wind: clean tech needs patient capital. University of Massachusetts; Mazzucato, M. 2013, The Entrepreneurial State.
144 CCC 2010. Building a low-carbon economy: the UK's innovation challenge. Committee on Climate Change, London.

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- The main technologies where the UK has developed some global leadership are marine energy technologies, waste-to-energy and wind technologies. However the UK is lagging behind in battery, fuel cell, solar thermal and nuclear technologies.

Box 3-3: Offshore wind policy and the importance of confidence

Over the past five years, the UK has established a leading position in the deployment of offshore wind. The UK's approach to offshore wind today can be contrasted with the UK attitude to onshore wind in the 1990s. At that time, policy focused on providing incentives to develop the least-cost wind technologies – but the process provided too little support, ignored barriers to new entrants, and failed to establish the nucleus of a domestic industry [145]. Offshore wind offers a substantial new opportunity, as the sector is still confronted with huge technology and business challenges crying out for innovative solutions. The UK should be very well placed to capture the benefits of overcoming these problems – and Government policy has been hugely supportive of the sector. While the December 2013 Autumn Statement made clear that government continues to support offshore wind, there is ongoing uncertainty about support beyond 2020 – particularly given the absence of a 2030 renewable energy target or power sector

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3.5.2 Economy-wide green conversion

As explored above, it is important for the UK to understand not only where comparative advantage might be gained in core markets. It is also important to understand how well the UK's innovation system is responding to the environmental imperatives of the 21st century economy.

Characterising economy-wide 'eco-innovation' performance is challenging, in part because data on environmental activities is often poorly represented in existing public statistics, and in part because of the inherent conceptual ambiguity in the idea of eco-innovation performance (i.e. which aspects of innovation are more important; how does one assess the relative 'green-ness' of different innovations, etc). The European 'eco-innovation observatory' is one of the few initiatives to attempt a consistent measure of national eco-innovation performance. On this index, the UK has consistently performed lower than our major competitors. As shown in Figure 20 below, the UK is almost exactly at the European average – well ahead of Poland, Hungary and Greece, but far behind the leading countries such as Finland, Denmark, Sweden and Germany.

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Ultimately, no single ranking scheme can capture the diversity of innovation activities and performance across the whole range of environmental goods and services. However, the UK's performance across these indices delivers some clear messages: the UK has some key areas of global strength, but overall performance in eco-innovation is lower than it could be. The UK clearly has the potential to do better, and the opportunity to take leading roles in key areas.

Patent data shown earlier suggested that global innovation is increasingly 'eco-innovation',

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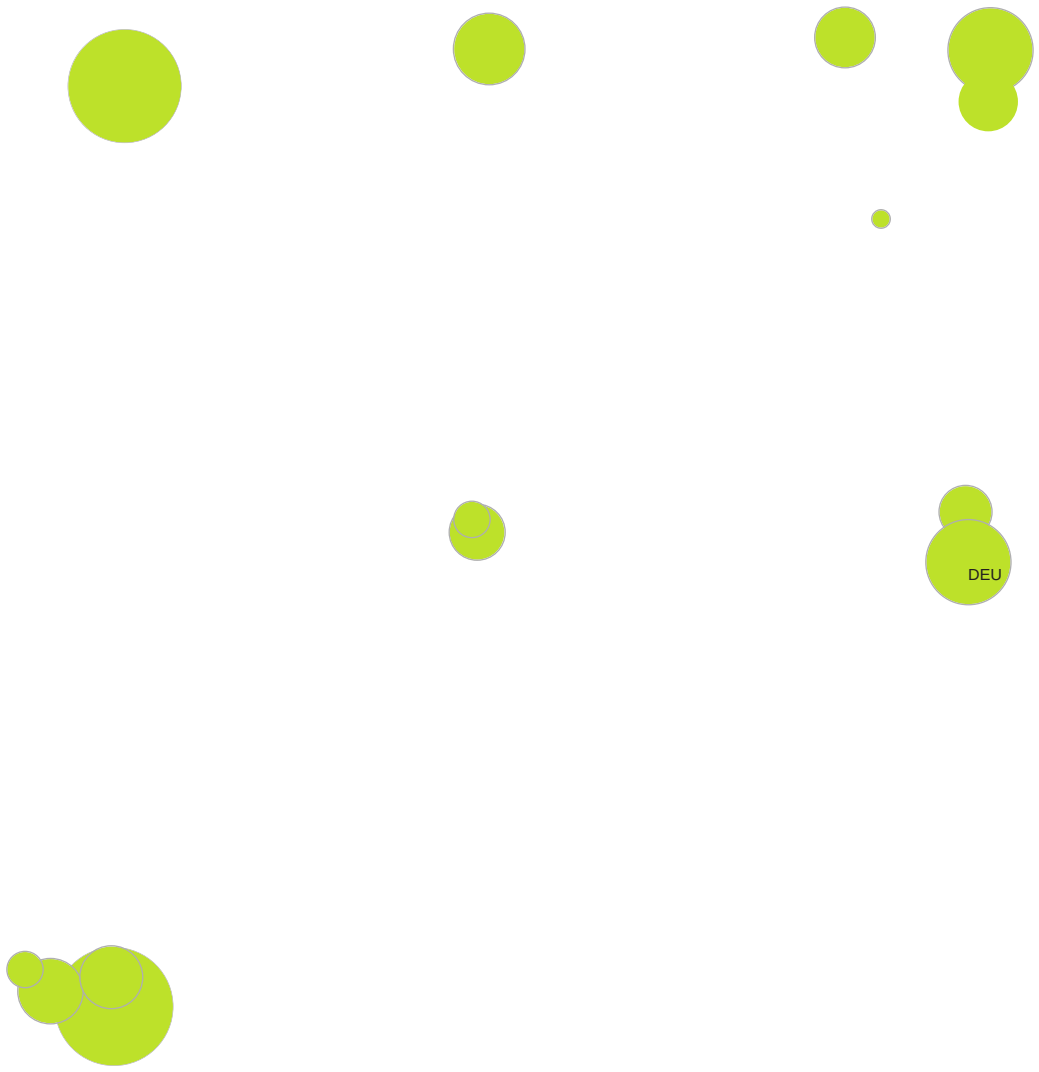

size, it is possible to assess the green innovation performance of sectors in which the UK already has comparative advantage. Note that this data, because it focuses on the manufacturing sector, does not highlight the important role played by 'green' financial and business service sectors in the UK's transition towards a green economy.

Reassuringly, there are several areas of manufacturing in which the UK is developing a green innovation advantage over major competitors. This is particularly exciting in those areas in which we have not traditionally had comparative advantage, as UK companies potentially threaten incumbents through green innovation. Importantly, these areas of opportunity include sectors of potential significance as core green technology fields, including manufacture of electricity distribution technologies and manufacture of motors and generators (see Figure 22). While the UK is a relatively small player currently in these fields (illustrated by circle size in the figure), it is encouraging to see green innovation leadership. Analysis of the trends within the data also show that a number of sectors have seen the UK moving from green innovation laggard to green innovation leader over the course of the last decade, including manufacture of lighting equipment, cooling and ventilation equipment, and various parts of the chemicals industry.

But the data also show that there are areas in which the UK needs to do more. In particular, while recent UK innovation and industrial policy has helped to generate comparative advantage in the aerospace and automotive sectors, patent data suggests that UK innovation in these sectors is less environmentally-oriented than those of competitors (see Figure 22). As the world increasingly moves towards tighter environmental standards and constraints, these areas of existing comparative advantage may be under threat if we fail to accelerate our green innovation system.

3.6 A green innovation strategy for industrial and economic success

Standard economic approaches to environmental technology policy typically start from the observation that such technologies suffer from two distinct sorts of market failure. First, environmental externalities mean that demand for such technologies does not reflect their economic benefits, because prices do not reflect environmental damage. Second, the market failures relating to innovation in general (particularly the difficulties for entrepreneurs of appropriating the full value arising from innovations) also apply to environmental technologies. The policy prescription has generally favoured a combination of 'demand-pull' measures in the form of environmental pricing (to fix the market failures around environmental externalities) and 'technology-push' measures in the form of R&D funding (to fix the market failures around innovation).

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prospects by dithering over its decisions over the Fourth Carbon Budget and 2030 carbon

compliance costs manageable (see Box 3-4). It is surprising that the HM Treasury's guidance for the appraisal of regulation and Government spending, the Green Book, contains no guidance on assessing the potential of Government action to stimulate innovation, despite supplements on a wide range of other topics (from 'optimism bias' to 'competition' and 'air quality'). Regulation isn't only about setting tough challenges. 'Nudge'[157] approaches to regulation change the choice framework through which decisions are made. Here the role of regulation is to establish the contexts – the 'choice architecture' – in which people are ultimately still free to make their own decisions but they are induced to change their behaviour towards greener choices.

Box 3-4: Innovation-friendly regulation: Japan's Top-Runner Programme

Energy efficiency of products is a classic area in which market signals for adopting more-efficient options appear to have a weaker effect on consumer decisions than economists expect. Regulators have responded by introducing minimum appliance performance standards, and energy labels to help consumers understand the implications of purchase decisions.

Japan has taken this approach one step further, by adopting a regulatory framework that, allied to Green Public Procurement (see below), drives up the minimum standard over time, based on rewarding the market-leading technology and removing the worst performing products from the market. While environmental economic text books continue to teach that a weakness of 'command and control regulations' is that they provide no incentive for innovation, this example shows that well-designed regulation can lead to considerable and ongoing pressure to innovate [158].

Fourth, innovative and green procurement . In times of austerity, governments must focus on value for money in procurement. But from an innovation perspective it becomes clear that smart procurement can yield dividends[159]. The importance of the NHS and BBC in the UK's pharmaceutical and creative industries respectively are well recognised examples[160]. Furthermore, governments can use green intelligent procurement to identify opportunities for savings in resources and energy, seeking innovative solutions and innovative business models that get the best value in both economic and environmental terms, so that government's considerable buying power is consciously used as one of the levers of public policy to facilitate a successful eco-innovation system.

157 Behaviour Change and Energy Use, Cabinet Office, Behavioural Insights Team https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/60536/behaviour-change-and-energy-use.pdf
158 Kimura, O. 2010. Japanese Top-Runner approach for energy efficiency standards. SERC Discussion Paper.
159 Edquist, C. and J. M. Zabala-Iturriagagoitia (2012). Public Procurement for Innovation as mission-oriented innovation policy. Research Policy 41(10): 1757-1769
160 NESTA, 2012, Plan I: the case for innovation-led growth.

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Government has introduced various schemes to use procurement to stimulate innovation. The continued development of the UK's Small Business Research Initiative, inspired by the successful US Small Business Innovation Research programme, is important. Forward procurement commitments, which commit Government to purchasing products or services that meet a given performance standard that currently is not available, have been successfully used in the past[161]. However, as the House of Lords Science and Technology Select Committee highlighted in 2011[162], progress has not been as great as it could have been. The Committee said that 'It is striking the number of documents and reports published in recent years that make recommendations about innovation in public procurement. Yet it is disappointing that we have seen no evidence of a systematic and coherent use of public procurement as a tool to stimulate innovation.' Clearly more progress could be made to use procurement to further innovation in general, and eco-innovation in particular, perhaps by following the Committee's recommendation that there should be 'a Minister in each Government department with specific responsibility for procurement and innovation'.

In addition to these demand-side measures, there is scope to promote a greening of innovation from the supply-side. Supply side 'horizontal' (i.e. not targeted) measures are typically framed as addressing particular system or market failures. Setting a clear strategic direction for a green economy provides greater confidence for investors and innovators alike. It is about the supply of innovation just as much as fostering expectations of future demand. Expectations and guiding visions play an important role in aligning innovation system players around common goals and problems, hence the rise of 'roadmapping' and other foresight mechanisms as innovation policy tools.

The direction and framing of research and innovation activities are shaped by social and policy influences. Recent years have seen a narrowing of the Government's articulated priorities for innovation and a near exclusive focus on economic growth[163]. To promote greener innovation, environmental objectives should be incorporated explicitly into the framework of decision-making around long-term science and technology priorities. While it is clearly right that the Haldane Principle applies to Research Council decision-making on programme design and grant allocation, ministers exercise considerable influence on the development of major priority areas[164]. Current pr

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In particular, recent years have seen the rise of the 'impact agenda', with Research Councils requiring academics to consider the kind of impact that their research might have. Though academics often read this as a thinly veiled attempt to shunt academic research towards more economically useful activities, the Research Councils' framing of impact is broad, incorporating both social and economic priorities. The environment, however, is not highlighted alongside (i.e. as the same level as) society and economy – researchers are therefore not given incentives to consider or articulate the environmental impacts that their work may have, unless they can frame these in terms of social or economic benefits.[165] This is a missed opportunity to embed environmental objectives alongside social and economic objectives in research policy. Finally, environmental objectives should be made more prominent in the mandate of the TSB, whose mandate is strongly framed around economic growth, rather than broader social objectives. While the TSB has shown some leadership in addressing environmentally relevant innovation areas, environmental objectives (and social objectives) should sit alongside growth as part of its core remit.

The intellectual property system can be used to provide a supply-side boost for eco-innovation. The UK's pioneering efforts to provide a fast-track for green patents has been seen as a success[166], providing the option for green entrepreneurs to accelerate IP protection, and the resulting access to finance and markets that this often provides[167]. The UK Intellectual Property Office green patent scheme was not only the first, established in 2009, but has also been most successful in terms of the acceleration of the examination phase, with the fast-track patents being granted 75% faster than typical patents[168].

3.6.2 Targeted 'vertical' (technology specific) measures: green industrial strategies

Vertical, targeted measures require the development of coherent strategies for key technologies. Such strategies need to be developed collaboratively with industry, and should together establish a clear vision of the green economy for the UK. The details of particular sectoral or technology strategies will be highly contingent on the technology field. Offshore technologies require the kind of innovative leasing approach that the Crown Estate has pioneered. Vehicle technologies may require partnerships with local authorities that can facilitate support schemes: in Norway, the city of Oslo has played a leading role in supporting the development of the market for both electric and hydrogen vehicles. Rather than attempt to develop a prescriptive set of policies that form the basis for 'green industrial policy', the following sets out core principles for such a policy within a coherent framework.

165 http://www.rcuk.ac.uk/documents/innovation/missionsei.pdf
166 UKIPO 2011. Environmental success as 100th green patent granted. Press Release from the UK Intellectual Property Office, 24 May 2011.
167 Dechezlepretre, A. 2013. Fast-tracking green patent applications – An empirical analysis. LSE Grantham Institute.
168 Dechezlepretre, A. 2013. Fast-tracking green patent applications – An empirical analysis. LSE Grantham Institute.

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A successful ‘vertical’ approach requires the following components.

1. Embedding green objectives within approaches to prioritisation and selection of core technologies and sectors . Government uses a range of processes for prioritising sectors and technologies for support, including foresight and technology roadmapping. In the context of the industrial strategies, Government has addressed this with analysis of areas of comparative advantage. In the context of a green economy strategy, there is a clear case for adding the

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activities funding low-carbon innovation. The thematic 'technology and innovation needs assessment' process formalizes the strategic vision and technology assessment for low-carbon technologies, and provides leadership. If successful, this kind of innovation needs assessment and co-ordination could be replicated across other strategic areas of eco-innovation, such as resource productivity, encompassing high-tech manufacturing and industrial design, and agriculture and ecosystems, encompassing the UK's agri-science strengths. Finally, the evaluation approach should embed precautionary appraisal[172].

3. Mission-driven R&D agencies and institutions to support key technology fields . The success of the US Defense Advanced Research Projects Agency (DARPA) in stimulating the US innovation system has been well documented. Other mission-driven R&D and innovation agencies, including the US National Institutes of Health, have also played a critical role in supporting innovation that underpins particular social and economic objectives. The establishment of seven Catapult Centres is an important step in developing the UK's innovation system. However, the scale and ambition of the centres is not yet commensurate with the challenge. Recent analysis has suggested that the centres should be 'bold, ambitious and enterprising' if they are to replicate the success of similar bodies elsewhere. In addition, the centres should:

- Build on existing regional strengths to support the formation of hubs and clusters . Regional strengths are a fundamentally important source of long-term competitive advantage and innovation success. Experience shows that building clusters from scratch rarely works, but that existing and emerging clusters can be effectively underpinned by a keystone public institution.
- Have a high degree of independence , with an expectation that many projects and initiatives will fail. An absence of failures is not a sign of success. It is as likely to be a sign of timidity and a lack of entrepreneurialism – but of course failures are difficult to manage effectively. Distancing the day-to-day running of innovation agencies from ministerial control helps to shield risk-taking innovation activities from the politics of short-term value-for-money debates.
- Be judged appropriately . Catapults should sponsor environmental innovations that are truly radical. It is important to ensure that performance metrics for such agencies are appropriate to this task. It is often assumed to be desirable to achieve high 'leverage' ratios of public funding to private investment, showing that public money is 'crowding in'

172 See EEA 2013, Late Lessons from Early Warnings II. European Environment Agency, Copenhagen; Stirling, A. (2008). 'Science, Precaution, and the Politics of Technological Risk.' Annals of the New York Academy of Sciences 1128(1): 95-110.

investment into target areas. But truly radical ideas will often be precisely those that are too risky to attract significant private finance in early stages. Judging programmes solely by their co-funding or leverage ratios would incentivise timidity on the part of programme managers.

- Link development with targeted early deployment in niche markets . Niche markets play a key role, particularly in fostering technologies that can enable more radical shifts in technological paradigm[173].

4. Develop long-term patient finance vehicles for green innovation . The Carbon Trust and ETI have been valuable vehicles for public investment in low-carbon innovation. These models could be expanded. As the British Business Bank takes shape, one option would be to consider establishing a dedicated green innovation investment arm or subsidiary.

5. A clearly articulated approach to the life-cycle of support . Understanding of industry and technology life-cycles makes clear that the timing of support is important. Support is most

champions. Sector and technology-field strategies must enable a diversity of approaches, business models and firms to participate. The German support system for the earliest wind turbines restricted support for each firm and design, ensuring that a diversity of approaches was developed[176]. This means ensuring that new entrants can access support as well as incumbents. Diversity is enhanced by decentralising control of innovation policy, enabling regions to pursue different models of support.

Box 3-5: Innovation, economic regulation and network infrastructures

In 'natural monopoly' infrastructures such as electricity and water networks, the Government's emphasis on competition as the driving force for innovation has been a clear failure. In energy networks this has been recognised, and Ofgem's new 'RIIO' price control process is driving a transformation of investment in energy infrastructure innovation for electricity and gas transmission and distribution. The Council for Science and Technology recommended a similar approach for water in 2009, but these recommendations have been more or less ignored, with Ofwat preferring to avoid explicit innovation incentives and rather assuming that increased competition combined with a 'totex' price control system will create sufficient incentives to invest in innovation [177]. The TSB conducted a review in 2011 and decided not to fund a water innovation platform, despite clear UK strengths and global export opportunities. This decision was at least partly taken because of low innovation and technological entrepreneurship within the regulated companies – itself partly a result of the structure of market regulation imposed by Ofwat. Adopting a specific innovation incentive within the price control could provide an important way of reinvigorating the innovation system around water technologies in the UK.

3.6.3 Beyond horizontal and vertical approaches: a systemic view of eco-innovation policy

The previous sections have introduced a series of 'horizontal' measures designed to foster a greening of UK innovation activity, and 'vertical' measures that characterise green industrial policy by focusing specifically on core technologies that are clearly required for a green economy. This final section brings these together into a multi-level perspective on green economic transformation.

176 McDowall et al, 2013. Ibid.
177 Ofwat 2011. Future price limits: a consultation on the framework.

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MACRO level	Carbon pricing and other environmental taxation Broader green economy strategy	Changing the macro-conditions for green technologies across the economy
MESO level	Regulatory regime (sector-specific legislative and regulatory frameworks) Strategic initiatives (public private partnerships/cooperative pilot programs) State funded programs (Public innovation procurement)	Enable emergence and growth of new green innovations
MICRO level	Integrating 'nudging' policies with other policies for deployment of clean technologies Beyond 'nudging' policies: policies that are differentiated by types and capabilities of firms	Changing individual and organisational behaviour within the given framework of incentives and constraints

Figure 23: Multi-level perspective on green economic transformation

At the macro-level, environmental pricing (through taxes or trading systems) generates both opportunities and constraints for private actors to search new technological trajectories or change their behaviour within the existing trajectories. This is the key requirement for investors in clean technologies to invest. However, pricing by itself will do little if there are not opportunities for new market niches to emerge and grow. These in turn depend on whether the state has been supportive of new technologies as sole sponsor, as co-sponsor, or as regulator which facilitates the emergence of new technology systems. However, new market niches and favourable price structures may not be sufficient to change behaviour of individuals and organisations. It is necessary to make it easier for individuals and organisations to maximise their long-term wellbeing while at the same time complying with environmental standards and reducing their carbon footprint. The role of government is to design environments and contexts – the 'choice architecture' – in which people are still free to make their own decisions but are encouraged to adopt behaviours more consistent with a green economy[178] (See Box 3-6).

The key message here is that all three policy levels are inextricably linked. Each of them by itself is insufficient to generate and maintain an economic transformation towards green growth. For example, there are serious limitations of nudge policies in the absence of market niches which in turn cannot be up-scaled without appropriate relative prices. Policy aims can rarely be achieved without the simultaneous presence of all three policy levels. In that respect, it is systemic policies

178 Richard Thaler and Cass R. Sunstein. Nudge: Improving Decisions About Health, Wealth and Happiness.

rather than market failure policies that are required. Obviously, the importance of different policy layers as well as modalities of their implementation will vary widely across countries, but a green strategy will not be feasible without some involvement of each of the layers. The diversity of multi-level policy profiles reflects different political philosophies and legacies as well as the nature of the 'green challenge'. In summary, it is the entire institutional context for green technology policy that is important, not just the specific policy instruments that should be deployed.

Box 3-6: The role of green 'nudges' in eco-innovation policy

The multi-lever eco-innovation policy structure above requires some explanation of the role of 'nudge' policies within this multi-layer framework, building on the discussion of behaviour change and behavioural economics in section 2. 'Green nudge' policies aim to foster changes in behaviour towards protecting the environment and the use of new energy- or resource-efficient technologies, drawing on insights from behavioural sciences[179]. Examples include regulations that create a greener 'default option', such as China's requirement that plastic bags cannot be given away for free, requiring the consumer to ask for and pay (even a nominal fee) for a bag; and 'peer comparison' approaches that provide information on the environmental impacts of a consumer's choice relative to neighbours or peers. The use of smart technologies opens up a great and as yet barely explored potential of smart technologies for green nudges [180].

There are clearly serious limits to green nudges, in the absence of available new technologies ready for up-scaling and diffusion as well as in the absence of macroeconomic incentives like CO_2 pricing. Hence, very often 'green nudges' may be tinkering on the margins. It is important to be clear about the strengths and weaknesses of nudges, and in particular to consider how nudge-approaches can fit within a broader policy landscape. Nudges are valuable for addressing problems that arise from limited behavioural responses to what are expected to be clear policy or economic incentives. Nudges thus need to be integrated into other policy instruments rather than treated as standalone devices that by themselves can solve problems that are in essence structural[181].

179 Baddeley, M. (2011), 'Energy, the Environment and Behaviour Change: A survey of insights from behavioural economics', Cambridge Working Papers in Economics CWPE 1162, Faculty of Economics, University of Cambridge

180 For example, a display unit connected to a 'smart' electricity meter could be installed in private homes to give consumers better real-time feedback of their energy consumption and savings. See further details in Oullier and Sauneron, 2011

181 Olivier Oullier and Sarah Sauneron, Social Issues Department, Centre for Strategic Analysis. 'Green nudges': new incentives for ecological behaviour' La Note d'analyse, March 2011, no216
http://www.strategie.gouv.fr/en/content/policy-brief-216-nudges-green-new-incentives-green-behavior-march-2011

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Nudge as conventionally perceived is primarily focused on individuals and their behaviour. However, a large set of issues related to behaviour which does not conform to rational expectations applies equally to organisations. Pro-environmental policies do not always have the expected responses from commercial enterprises, and greater understanding is needed of how unexpected behaviour of business can result in policy failure. This implies a need to go beyond conventional 'individual' nudges to nudging organisations.

3.7 Conclusions on innovation

This section has discussed the vital role of Government in supporting innovation and specifically in shifting the UK towards eco-innovation. It has highlighted the UK's under-performance in some key areas of green technology as well as the opportunities to develop competitive advantage, and the need for Government to set long-term direction for innovation policy in order to generate investor confidence. It has also discussed a cross-cutting approach to supporting innovation, combining a horizontal and vertical approach.

Summary of recommendations on innovation

- The development of a new green industrial strategy targeted at technologies that can underpin emerging green industries , with a clear approach for the selection of technology priority areas, the enhancement of existing 'mission-driven' R&D agencies, the development of long-term patient-finance vehicles for green innovation, better downstream/upstream alignment, and support for innovation in business models.

- Embedding green objectives within the governance mechanisms for innovation and in particular reviewing existing industrial strategies to ensure that they adequately address the imperative for green innovation within each sector, and a clear mandate to pursue environmental as well social and economic objectives for Agencies responsible for delivering funding for research and innovation

- Creating demand-pull for green innovation across all areas of the economy, including through strengthening existing environmental policies and ensuring that regulations have been developed in such a way as to provide incentives for innovation, and enhancing public procurement processes to ensure that they are used most effectively to stimulate green innovation.

Infrastructure

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Infrastructure choices today shape the environmental performance of the economy for decades into the future. Thinking carefully about infrastructure is vital for achieving a green economy.

As the UK moves into recovery there is a consensus that more needs to be done to stimulate investment in infrastructure. The argument of the UCL GEPC is first to recognise that choices must be made, and that infrastructure that is compatible with a green, resource-efficient economy should be prioritised.

Second, a credible and clear vision for infrastructure and the institutional structure required to deliver it will enable infrastructure investment at a lower overall cost. Committing to a credible green economy strategy can help stimulate infrastructure investment that will bolster the emerging recovery.

To do this, a green infrastructure strategy is required . This should set out clear criteria for infrastructure project evaluation, and it should be supported by a set of appropriately designed institutions across national and local government, including:

- Expansion of the Green Investment Bank;
- Creation of a National Infrastructure Bank;
- Creation of an independent infrastructure governance body;
- Empowerment of cities to drive green infrastructure investment , through a collective municipal agency for green bonds.

The UK is in great need of increased levels of investment in infrastructure. Much of its infrastructure is ageing, and levels of investment have not kept pace with the needs of a modern economy[182] (see Figure 24). The UK's global competitiveness ranking for 'quality of overall infrastructure' was 24th in 2012-13, below all the other G7 economies except Italy[183] (and a decline from its ranking of 19 in 2007). In a 2012 survey by the CBI, nearly two thirds of companies judged the UK's infrastructure unfavourably relative to that of other EU countries[184]. The OECD has consistently identified investment in infrastructure, and especially in transport, as a priority for the UK[185].

182 CBI 2011, Making the right connections; Crafts, N. 2012 Creating Competitive Advantage: policy lessons from history.
183 World Economic Forum, 2012-2013. Global Competitiveness Report.
184 CBI, 2012. http://www.cbi.org.uk/media/1744517/is2012_final.pdf
185 OECD, 2013. Economic Reforms: Going for Growth. See also various editions of the OECD Going for Growth series and its regular Economic Surveys

Infrastructure

Figure 24: Gross fixed capital formation as a percentage of GDP in G8 countries. Source: IMF[186]

As the Prime Minister said in 2012, ‘if our infrastructure is second-rate, then our country will be too’[187]

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4.1 Infrastructure for a green economy: policy rationale for national governments and cities

A set of core economic and political reasons underlie the need for a green economy strategy to address infrastructure. Most acutely, the presence throughout the economy of environmental externalities ensure that the private sector has no motive to build infrastructure that is green unless public policy provides incentives to do so. The arguments for public involvement in shaping infrastructure provision become much stronger once environmental concerns are taken into account.

From a green economy perspective, one of the most important features of infrastructure decisions relate to processes of 'lock-in'[192]. Once built, infrastructure shapes the context in which the economy develops, and infrastructure can thus enable or constrain a greener development path. The risk with the Government's infrastructure policy is that the UK will build itself into an unsustainable corner from which retreat will be costly. The long-lived and structural character of infrastructure means that short-sighted investments now may lock in high-resource, high-carbon and high-waste patterns of economic activity, which will become an increasing burden in decades to come. Infrastructure owners and operators are not always exposed to the full economic risks of infrastructure failure, reducing incentives to ensure adequate resilience in the face of climate change, for example[193].

Unfortunately, the current institutional arrangements for promoting infrastructure investment – with the exception of the Green Investment Bank – fail to establish clearly the need for compatability with long-term environmental goals, or to reduce exposure to environmental and resource risks. The risk is that we build a future Britain that is less resilient to expected resource constraints and climate risks, that is less responsive to the economic changes brought about b.6(f)-5'Ionsr exampl2lxa ocesse:d amulti-ldeveh

Infrastructure

4.1.1 Clear role for national governments

As noted above, the basic characteristics of critical network infrastructures provide a strong economic rationale for government involvement. In past decades (and still today for some areas of infrastructure, particularly roads), that rationale has made the case for public ownership and provision of infrastructure. While this overcame many problems associated with market failures, it introduced a set of problems of its own. The 1980s saw a belief that private ownership and competition, coupled with effective regulation, would offer a solution. Experience has shown that the model adopted since the 1980s did not result in sufficient levels of investment.

The problems associated with an excessive public deficit clearly limit the potential scale of public investment. Any solutions must not permanently expand government debt. However, private long-term financing is potentially available, in quantity, particularly from pension and insurance companies. Under present institutional arrangements, the private sector will not do the job alone – and government must act to mobilise this long-term financing. Leveraging private sector investment in green infrastructure is thus the central aim of a green infrastructure policy. With these conditions in mind, government's role is mainly in: setting the institutional framework; and, where necessary, assisting with construction risk.

4.1.2 Roles for cities

It is impossible to think about an effective infrastructure strategy for a green economy without addressing the role of cities. While national and devolved governments make major decisions about large national infrastructure projects like airports and high-speed rail, it is municipal governments that shape much of the nation's infrastructure. Enabling and empowering municipal governments to leverage investment for green infrastructure is critical.

Urban areas are well-placed to lead the resource-efficient transition, and benefit most directly from it. Cities are created to overcome the problems of distance, and efficiency is thus part of their defining essence. Cities are also vulnerable to climate impacts such as heat, water shortages and floods. But because, in the UK, they are small players in governmental terms, vulnerability often does not translate into local action to reduce emissions. More encouraging is the fact that cities also stand to benefit from green economy policies through increased efficiency; innovation; reduced noise; reduced congestion; reduced pollution, and an attractive

complexity mean that specific problems such as congestion, waste, poor access to education, crime, and high levels of deprivation require considered, city- specific public intervention. At the same time, high population density and compactness can allow for economies of scale and collaboration. It is perhaps unsurprising that major world cities are increasingly taking the lead in resource-efficient action and setting strong emissions targets. Examples include New York (30 per cent cuts in greenhouse gases over 2007-30), Los Angeles (35 per cent cuts over 1990-2030), Seoul (40 per cent cuts over 1990-2030), and Hong Kong (50-60 per cent cuts over 2005-20).

Environmental impacts from cities are associated with differences in settlement patterns, with denser, more compact cities tending to have significantly lower average per capita emissions. As the World Bank, OECD and others have shown[194], cities of similar per capita incomes and similar populations can have vastly different resource calls (as proxied by greenhouse gas emissions per head). Many cities in North America such as Phoenix, Atlanta and Cincinnati, built around a model of sprawling suburbs and extensive car use, have emissions which are up to five times higher than cities in Europe and Asia (such as Copenhagen, Amsterdam, Barcelona or Hong Kong) which are built on the model of dense residential concentration and extensive public transport. Yet infrastructural and behavioural lock-in now makes it hard to retrofit resource-hungry cities, such that these cities will be at a major disadvantage as the costs of resources increase. Residents of such cities have little to gain from policies to discourage car use and provide cycle and pedestrian facilities, in contrast to denser cities where city authorities are held accountable, and rewarded, for the provision of such resource-efficient facilities.

Consequently, cities risk locking in infrastructure, technologies, and behaviours that will be very difficult to reverse retrospectively. Cities with limited urban sprawl and integrated urban transit systems have, in many cases, become affluent with low emissions per head. Their relative resource efficiency is mainly a result of greater transport energy efficiency due to reduced distances and greater shares of green transport modes; also greater energy efficiency in buildings due to lower surface-to-volume ratios of more compact buildings and lower embedded energy demand for urban infrastructure due to high utilisation. But compact, well managed cities with intelligent infrastructure can also be more attractive to footloose workers than suburban or rural

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Despite the fact that denser cities are more resource-efficient and generate significant savings in operating costs, suburban living remains popular, especially in cities whose urban centres suffer neglect, pollution, crime and outward migration of people and wealth. So dense cities need to be carefully planned to attract the wealth-creating individuals who could choose other options. Not surprisingly, cities that today are regarded as green leaders have a track record in long-term and integrated planning, particularly related to land use and public transport infrastructure. This requires forward thinking because investing in resource-intensive development may be cheaper in the short run, requiring less careful planning. However, it is likely to be more costly over the medium term and very difficult to reverse. It is estimated that people in Portland, Oregon, save US$2 billion annually through three decades of co-ordinated policies to change land use and transport systems. Measures include modest increases in building density, light rail transit schemes and policies to encourage walking and cycling. In many European cities, recycling levels are in the region of 50 per cent of domestic waste, with Copenhagen sending a mere three per cent of its waste to landfill.

Integrated ICT technologies will help make dense complex cities work efficiently. A networked broadband digital infrastructure can connect people to people, people to city systems and city systems to city systems, allowing cities and residents to respond to changing circumstances in near real time. City authorities are already of th7tcloer co che i citieznse, bthe physcanly tnd

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4.2 UK infrastructure policy: the Government's approach and the critics' responses

The UK Government has recognised the need for a more active role for central government in shaping infrastructure investment, and has dedicated substantial effort towards stimulating greater private sector investment in infrastructure. The Government's emphasis in the critical role of private sector finance for infrastructure is well illustrated in Figure 25.

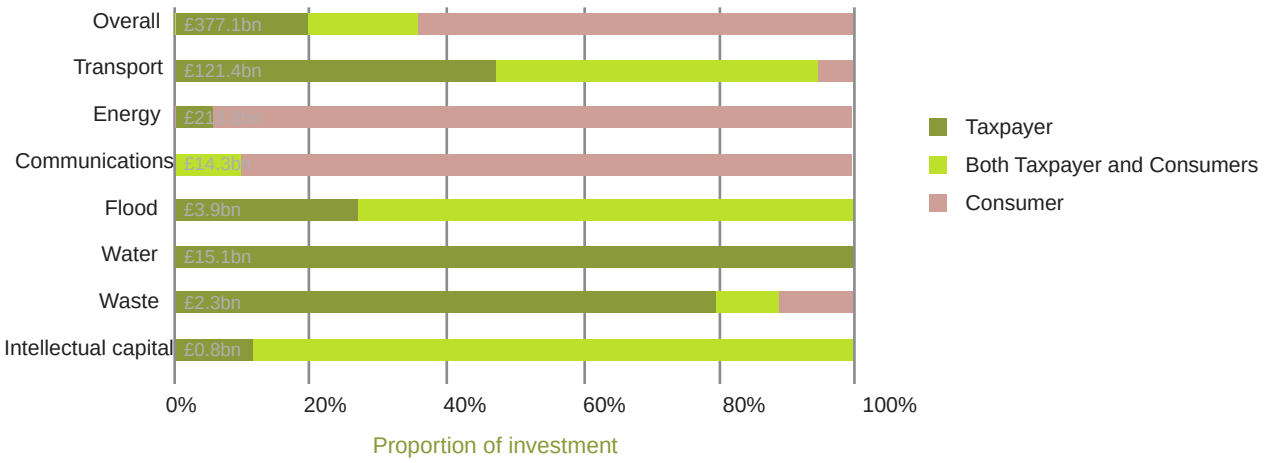

Figure 25: depicts the sources of funding for investment from 2015 onwards; it clearly shows the relevance of private participation towards the realisation of the UK National Infrastructure Plan, with the majority of infrastructure being funded wholly or partly by the private sector. Source: HM Treasury, December 2013.

The challenges of stimulating private sector investment have been made more acute as a result of the structure of regulation and incentives in which such investment takes place, and in particular the regulations put in place in the wake of the financial crisis. Basel III introduces stricter liquidity standards and these will discourage banks from undertaking long-term investments such as in infrastructure. With these new restrictions on banks, the burden of financing infrastructure therefore rests more on institutional investors such as pension funds. Furthermore, new insurance regulations (Solvency II), which are applicable to pension funds, also discourage pension funds from stepping in to fill the gap created by the banking sector. While the December 2013 announcement that insurance companies are willing to invest £25bn in UK infrastructure following the completion of negotiations around Solvency II is to be welcomed, it remains to be seen whether this will result in

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significant money being delivered, as several commentators have noted[195]. Finally, it has also been argued that the structure of taxation and financial regulation has created incentives for short-termism in equity markets, and that this has hindered investments into infrastructure[196].

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Box 4-1: The Green Investment Bank

The Green Investment Bank

The Green Investment Bank (GIB) is a financial lending institution whose primary focus is to invest in renewable energy and low-carbon projects located within the United Kingdom. Officially launched in November 2012, the GIB was created by the UK Government to invest in and attract other finance to projects that can help the UK meet its renewable energy and carbon reduction targets in 2020 and 2050. The GIB is wholly owned by the Department of Business, Innovation and Skills, and has received from the UK Treasury a total of £3.8 billion. To put this figure into perspective, Germany's

the UK Treasury's priority is to meet its reduction target on the net public debt deficit– which it does not foresee achieving by 2016/17. This makes far more difficult the realisation of the GIB's aspiration to raise £15 billion from the private markets in 2015. Such issues create a major challenge for the ability of the GIB to raise capital that is independent of direct Government budget allocation.

4.2.1 What's missing from the Government's approach?

A range of commentators have made proposals for boosting UK infrastructure investment. Five issues stand out:

- Vision, direction, confidence and credibility . Current initiatives are important but they do not do enough to address a major barrier to infrastructure investment that supports a green economy: perceived policy risk. Investors need to have confidence in the expected returns and risks of an investment. Infrastructure investments face significant regulatory risks and the Government could intervene directly to minimise them by establishing a more credible infrastructure strategy. The Public Accounts Committee said of the Government's infrastructure plan in April 2013:'we are not convinced that the current proposals represent a rigorous plan with clear priorities for action or with a clear programme for delivery.' This view has been echoed by others (for example, most recently by the CBI in December 2013[200]).
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numbers. However, there are good reasons for thinking about how – in the longer term – such accounting practices establish or undermine the conditions under which the UK is able to invest in infrastructure at a sustainable rate.

- Public capital spending . The policy initiatives examined above have all occurred in the context of reduced levels of public capital spending, as the Government has focused on deficit reduction. There is much debate about the appropriate balance between deficit reduction and public spending, and it has been repeatedly argued that the argument for higher levels of capital spending from the UK Government is strong[202]. The prominence given to infrastructure capital spending in the June 2013 Spending Review suggests that Government has at least partly accepted this argument – though public sector capital spending remains low.
- The need for long-term state investment vehicles : a state infrastructure bank. Many countries finance certain kinds of infrastructure through a state investment bank mechanism. Recent years have seen increasing calls from across the political spectrum for a UK infrastructure bank[203], or for infrastructure to be included within the remit of a British Investment Bank[204]. The Government has made a strong step in the right direction with the establishment of the Green Investment Bank (GIB), but there are good arguments for extending this approach.

A green economy perspective echoes many of these concerns and suggestions. Beyond this, however, the major issue from this perspective is that the structures that currently exist for the governance and financing of infrastructure are not up to the task of re-orienting infrastructure investment to a green economy path.

4.3 Infrastructure for a green economy: choices and policy proposals

A green economy strategy provides a coherent basis for prioritising and directing infrastructure development. Rather than making decisions in response to the lobbying of particular industry groups or the personal enthusiasm of individual ministers, a decision framework based on a green economy can provide investors with greater confidence in the broad long-term direction of infrastructure policy. If embedded in institutional frameworks that are long-lived and relatively difficult to change, this can help reduce perceived policy risk. In this light, broader environmental and economic policy, particularly green fiscal reform, which signals long-term priorities, is an important part of an infrastructure policy. The important point here is that a broad package of

202 IMF 2013, World Economic Outlook, October 2013; CBI Infrastructure Survey3; CB

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green economy measures taken together, and encompassed by a vision of a green economic future for the UK, amounts to more than the sum of its parts: a coherent and credible long-term strategy can reduce the policy risk associated with green infrastructure investments.

Unfortunately, a number of recent decisions and announcements have undermined any perception of a priority focus on low-carbon infrastructure. The June 2013 spending review announced an expansion of capital spending on roads, described as 'the largest road investment programme since the 1970s'. Road maintenance has desirable stimulus properties (particularly speed of implementation), and roads are clearly important for supporting the economy. The focus of public capital spending on roads rather than low-carbon infrastructure may not be surprising in itself, as low-carbon infrastructure is mostly privately financed and hence not prone to being announced by the Government – unlike roads. The problem is that these announcements contribute to a sense of a change in direction which may harm the investment climate – even if they do not in themselves represent such a change. It is particularly unfortunate that the road investment announcements were not made alongside the strategy for promoting low-carbon vehicles, announced just a few weeks later.

Similarly, the high-profile support for capital spending on shale gas exploration and development represents support for an industry whose UK costs and environmental impacts, and compatibility

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water management. This therefore includes ‘natural infrastructure’ (itself often called ‘green’ infrastructure), such as flood meadows and urban trees. It also includes key infrastructures such as smart electricity networks and transmission connections that enable substantial penetration of renewable energy technologies. These types of infrastructure must be prioritised.

Box 4-2: Indecision does not keep options open: regulatory uncertainty and gas distribution infrastructure

The UK natural gas distribution infrastructure is a large, networked, mature and hugely important part of the UK’s energy system. The gas network delivers far more energy to homes and businesses than does the power grid, though it is the latter that receives most attention. As the gas network ages, it has become necessary to re-invest to ensure safety, and the current regulatory framework provides incentives for around £400 million each year in gas grid upgrading.

The problem is that it is almost impossible for the UK to meet carbon targets while continuing to use natural gas as the major domestic heating fuel. This inconsistency between the statutory carbon targets and gas network regulation is beginning to generate considerable uncertainty. While investment is still forthcoming, it is quite possible that this investment could result in higher costs of decarbonisation in the future, as it will help to lock in domestic use of gas. The Government has only recently recognised that this issue needs to be addressed, but it is by no means clear who is taking responsibility for making the big strategic decisions about the gas network, a major infrastructure asset. A clear strategy now could ensure the long-term greening of the gas network (such as through injection of biogas or through ensuring that the network would be fit for use transporting hydrogen). Instead, indecision is creating the likelihood of lock-in resulting in higher future costs.

Government’s stated objective within the heat strategy is to avoid ‘picking winners’. However, when lock-in is a powerful force, inaction does ‘pick winners’ - but by default rather than by design.

Second, there is a wide category of infrastructure that can be compatible with a green economy if it is developed in a responsible and intelligent way. This includes both major new infrastructures such as high-speed rail, for which an environmental case can be made at a general level, but for which the devil is in the detail of project specifics. This category also includes infrastructures that are clearly necessary (at least today), such as water infrastructure or roads, but that must be ‘greened’ in order to be compatible with a green economy. For example, gas distribution grids are

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important currently for providing gas for heating, but in the long term, use of natural gas as the dominant heating fuel is not compatible with climate change targets. Gas distribution infrastructure investments must be compatible with options to develop greener gas, such as biogas or hydrogen (Box 4-2).

Finally, there is a category of infrastructure that is unlikely to be compatible with a green economy. This includes the infrastructure that supports sectors whose activities are very difficult or impossible to reconcile with a green economy if they continue to grow rapidly without great

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4.3.2 Articulate a clear strategy for a green economy, setting out what this means for the infrastructure plan

An infrastructure plan for a green economy must:

- Provide a coherent vision that underpins what this country's infrastructure requirements are:

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– Increase the capitalisation of the GIB by £1 billion . Dedicating public capital spending to this area of green infrastructure increases confidence in the overall green economy strategy.

– Expand the remit of the GIB to include community energy schemes , subject to a renewed State Aid clearance. The decision to exclude this from the original priority list was in part taken because of fear of competing with private sector financing of such schemes. However, the only significant private financing of such schemes has now exited this market (The Cooperative Group), and the decision to exclude these schemes should be revisited.

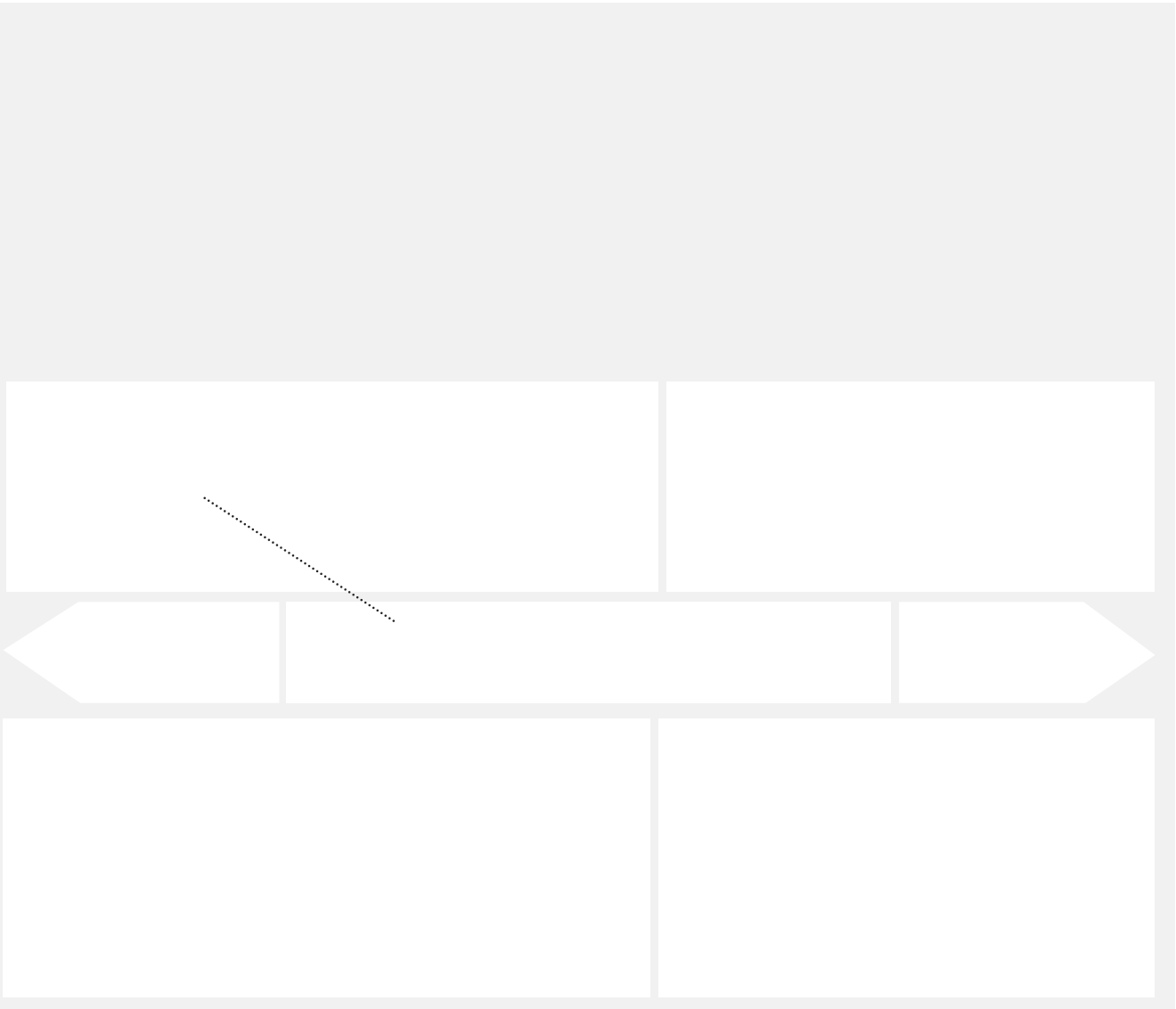
• Accelerate the roll-out of broadband infrastructure . ICTs are in themselves no green panacea, but they create opportunities for innovation and resource efficiency. An effective ICT infrastructure is thus an important enabler of a green economy. ICTs are also key for enabling the smarter management of existing infrastructure, such as energy systems (Box 4-3).

Box 4-3: Supporting investment in infrastructure required for a green economy

The UK Government estimates that £110 billion must be invested in the next decade to replace power plants and upgrade the UK's ageing electricity infrastructure. At the same time, new challenges are emerging, not least the need for:

- optimizing the supply and demand of electricity from multiple generation and demand centres (this includes micro-generation supply from residential and commercial users)
- integrating and smoothing the variability of renewable energy into the grid
- addressing increasing electricity demand from consumers (including electric vehicles).

There is a well-recognised opportunity to create a 'smarter' power system through digitizing and automating electricity technologies. This supports more efficient and dynamic decision-making on balancing the supply and demand of electricity and reducing unnecessary energy losses through enhanced detection and sensing capabilities. Real-time pricing and energy system information can provide consumers with dynamic pricing, but beyond this can enable active demand-side management through responsive appliances. Cloud technologies can also be used to synchronize the network of appliances within the home to create a home energy management system, enabling greater flexibility for consumers to either engage in – or automate and ignore – energy optimisation in the home. This opens scope for new energy service company business models to help consumers install the necessary technologies and manage their energy consumption.



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Armitt Review. This body would have a sustainable development duty, including a duty to consider climate change adaptation. Achieving long-term carbon budgets will require significant investment in low-carbon infrastructure. Any carbon-intensive infrastructure that is built in the coming decade should be considered in terms of the additional burden that it will place on future policymaking and infrastructure decisions, i.e. making it even tougher to meet longer-term targets, and perhaps necessitating even lower-carbon solutions. A key role for this body would therefore be to apply detailed analysis across a range of criteria (economic, social and environmental) in assessing infrastructure proposals. This would embed the broad long-term objectives of policy – as set out in a strategic infrastructure plan – within the institution making decisions about specific projects.

4.3.5 Empowering cities to lead in greening urban infrastructure

The previous discussion set out the case for cities to play a key role in delivering a greening of infrastructure. Here we make specific recommendations to help them to achieve this.

Enabling and encouraging green municipal bonds . Municipal bonds are a potential policy option for local authorities to use in attracting private infrastructure finance. In the US, municipal bonds have been a long-standing part of the infrastructure financing landscape; nonetheless municipal bonds directed to green infrastructures (particularly non-essential infrastructures such as alternative energy production, pollution monitoring systems, etc.) have been more exposed to high default risks as in the case of US industrial development bonds. The model that is increasingly popular in Europe is the Nordic System with the Swedish Kommuninvest seen as a particular success[207]. For instance, a number of French municipalities have launched 'sustainability bonds[208]. The resurgence of interest in municipal bonds in the UK is in part due to higher costs (and limited available volumes) of finance from the Public Works Loan Board in HM Treasury since 2010, and in part due to a new striving for more financing powers for local authorities. Growth in the municipal green bond market is highlighted by HSBC as one of five key trends in the global climate-related bond market[209]. In 2012, the Local Government Association suggested creating a collective agency for facilitating municipal bonds, as is used elsewhere[210] Some larger UK local authorities have already started to use bonds of this kind, with Leeds issuing £100 million in bonds to finance social housing projects in 2013[211]. Support for the

207 HSBC 2013. Bonds and climate change: the state of the market in 2013.
208 Ibid. (HSBC 2013. Bonds and climate change: the state of the market in 2013.)
209 Ibid. (HSBC 2013. Bonds and climate change: the state of the market in 2013.)
210 LGA 2012. Local Authority Bonds: a local government collective agency.
211 Khalique, 2013, Leeds puts municipal bonds on the UK map. Financial News, July 3rd 2013.

development of an agency with a mandate to supply locally initiated green infrastructure – including energy-efficient new housing development – could be an important enabler of green economy strategies.

Enabling leading cities to go beyond national minimum standards

The Government should keep in place the powers of local authorities granted under the 2008 Planning and Energy Act that enable more stringent energy rules, such as the so-called 'Merton Rule'. It is local authorities, in discussion with the developers in their local areas, that are able to determine the appropriate balance of regulatory requirements to drive efficiency and innovation within the built environment.

Box 4-4: London Green Fund and JESSICA Initiative

The structure and operational features of the European Investment Bank's JESSICA energy-focused Urban Development Funds (UDFs) have been established in the context of various energy-focused integrated plans for sustainable development covering Greater London.

The London Green Fund is the Holding Fund managed by the European Investment Bank established in October 2009 to invest in carbon-reduction initiatives as part of the 'London Plan'. In total, the fund is worth £100 million:

- £50 million from the London European Regional Development Fund Programme
- £32 million from the London Development Agency
- £18 million from the London Waste and Recycling Board

The London Green Fund is composed of two sub-funds which are the actual energy-focused urban development funds. The two UDFs operating under the London Green Fund, which have been structured, selected and invested by the Fund, combine London's efforts to deal with climate change issues in addition to other sustainable urban development objectives promoted by JESSICA.

The funds are targeted towards the financing of the three biggest carbon- reduction opportunities for London: energy efficiency, energy creation from waste, and decentralised energy projects.

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Particular aims have included improvement of building efficiency, refurbishment, new

Resource efficiency for green growth

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Resource efficiency for green growth

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Resource efficiency is an important emerging issue. Resource constraints increasingly threaten long-term prosperity, and the economic opportunities of increasing resource efficiency are correspondingly large.

The policy options for pursuing resource efficiency are well known, with various approaches implemented in different countries and at the European level. There is thus considerable policy experience, and some policy success, from approaches to improve resource efficiency.

While the UK has demonstrated policy innovation and leadership on some of these issues, there is a need to increase ambition if the potential benefits are to be secured.

- We recommend UK policies to increase resource efficiency through economic instruments; regulations on waste and energy efficiency; facilitation of industrial symbiosis; review of waste definitions and product specification; and intensification of green public procurement .
- We recommend EU policies to increase resource efficiency through harmonisation of environmental taxes; extended producer responsibility; regulations on waste exports; and eco-design .

5.1 The imperative of resource efficiency

There is now an extensive evidence base indicating the desirability of greater resource efficiency as a means of improving resource security within the UK economy. The concept of resource security relates to the capacity to access necessary resources at competitive and stable prices, thus limiting the impact on the economy of price volatility. Maintaining an indigenous production base may contribute towards this aim and, in recent years, both food security and energy security have been increasingly accepted as important national policy objectives.

The economic risk of high and rising resource prices is well expressed by two graphs. Figure 27 shows a long-term index of commodity prices. It can be seen that the year 2000 was the low point of a 100-year trend of falling commodity prices. It can also be seen that this 100-year price fall was more than undone by price increases over 2000-2010.

Resource efficiency for green growth

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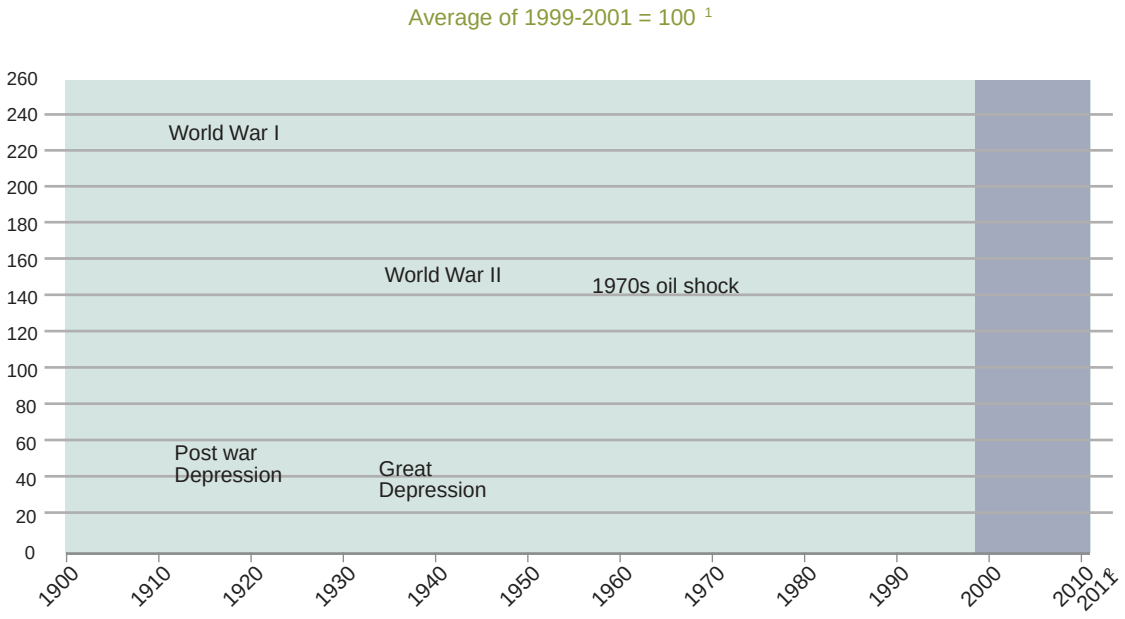

1 Based on arithmetic average of 4 commodity indexes: food, agricultural raw materials, metals, and energy. Each index was weighted by total world export volumes from 1999 to 2001 at indexed prices (in real terms) over the same time period. Energy index excludes gas prices prior to 1922, for which data are unavailable.

2 Based on average of first 4 months of 2011.

Figure 27: McKinsey Global Institute Commodity Price Index. Source: Dobbs et al. 2011[212], Exhibit E1, p.5

Figure 28 shows the development of commodity prices over 2000-12, a time of major economic downturn when, as in the 1920s, one might have expected a major price fall (see Figure 27). Figure 28 shows that all the major commodity groups did experience a fall in prices over 2007-09, but none of the prices fell back to the level even of 2005, and all have rebounded since to equal or exceed their average annual values before the downturn.

212 Dobbs, R., Oppenheim, J., Thompson, F., Brinkman, M. and Zornes, M. 2011 Resource Revolution: Meeting the world's energy, materials, food and water needs, McKinsey Global Institute, http://www.mckinsey.com/features/resource_revolution

Resource efficiency for green growth

Figure 28: Commodity real price indices for four commodity groups, 2000-12, 2005=100.
Source: World Bank Global Economic Monitor Commodities Database, http://databank.worldbank.org/data/databases.aspx?qterm=commodities, Accessed August 16 2013

The reason for this upward price movement is quite simply strong, sustained economic growth in emerging economies, resulting in enormous resource-intensive infrastructure construction and unprecedented numbers of people either becoming or about to become middle-class consumers – one estimate is of 3 billion more middle-class consumers by 2030[28], an increase of about 3 times the total global middle class in 1990. These new consumers are very likely to want the energy, housing and transport infrastructurnt

Resource efficiency for green growth

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5.2 The economic opportunities of resource efficiency

There are now many calculations that strong actions and investments to increase resource efficiency can generate economic benefits over the short, medium and long terms, rather than costs. One estimate puts these benefits at $2.9 trillion in 2030, of which 70% have an internal rate of return on investment of more than 10%[217].

At the European level, a report for the European Commission[218] estimates that European businesses could reap net benefits from resource efficiency measures based on current prices and technologies of€ 603 billion. In the UK, as shown in Figure 29, a study for DEFRA estimated

Resource efficiency for green growth

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Box 5-1: The European Resource Efficiency Platform [224]

The European Resource Efficiency Platform (EREP) was set up in 2012 and consists of five European Commissioners, members of the European Parliament, Member State ministers, business CEOs, and representatives of academia, NGOs and civil society. It issued a Manifesto for a Resource-Efficient Europe in December 2012 and recommended 'Action for a Resource-Efficient Europe' in June 2013, with the objective to create growth and jobs; provide incentives to overcome barriers to improving resource efficiency; put a proper value on resources; provide clear information and measure progress; and promote new business models. The recommendations are summarised below [225].

1. Set objectives, measure and report progress

The EU should set ambitious, credible targets as soon as possible to improve the overall resource productivity of the EU economy

2. Improve information on environmental and resource impacts

Organisations should measure and report progress in their environmental performance, and help develop common methodologies for measuring the footprint of products and services with a view to their use in policy development. … The EU should work towards a generally accepted binding reporting framework

3. Phase out environmentally harmful subsidies

The EU and Member States should as a matter of urgency phase out environmentally harmful subsidies (with the OECD definition in mind), with special emphasis on subsidies to fossil fuels and the use of water in agriculture, energy and industry. In the context of the European Semester process, the Commission should monitor and propose recommendations to phase out environmentally harmful subsidies and … encourage Member States to shift the tax burden away from jobs to resource use in order to promote resource efficiency.

4. Moving towards a circular economy and promoting high-quality recycling

EU waste policy … should set the right price signals through market based instruments (payment schemes, charges and taxes), accompanied by technical criteria and carefully targeted bans if needed. The EU and Member States should develop guidance in order to encourage, expand and improve Extended Producer Responsibility schemes.

224 See http://ec.europa.eu/environment/resource_efficiency/re_platform/
225 For full text see: http://ec.europa.eu/environment/resource_efficiency/documents/action_for_a_resource_efficient_europe_170icien

Resource efficiency for green growth

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5. Improve resource efficiency in business–to-business relations

Principles for sustainable sourcing standards should be developed and piloted for priority materials and commodities by relevant stakeholders, through voluntary schemes led by industry and retailers. … The possible use of a 'product passport', building on the existing Environmental Product Declaration, should be explored … The EU and Member States should foster industrial symbiosis by promoting a pan-European network of industrial symbiosis initiatives.

6. Taking forward a coherent, resource efficient product policy framework

The EU should adopt a more coherent product policy by mainstreaming, consolidating and ensuring consistency among existing instruments (ecodesign, ecolabel…) and closing loopholes. …This would cover warranties, durability, upgradability or recyclability requirements, eco-design requirements, as well as indicators, benchmarks and financial and non-financial incentives.

7. Deliver a stronger and more coherent implementation of Green Public Procurement

In order to operationalise the existing 50% Green Public Procurement objective, the EU should develop a systematic monitoring mechanism based on real public tenders and establish a European network to exchange good practice, standardise approaches and develop guidance on issues such as life cycle costing methodologies and use of labels.

8. Develop instruments for SMEs

Building on best practices at national and regional level, Member States should develop locally tailored support, combining resource efficiency audits/consultancy, access to finance and advice, and skills development for SMEs. The Commission should support networking between organisations running such schemes. Specific mechanisms for financing resource efficiency in SMEs should be developed, for example through the EIB.

As is apparent from the breadth of the measures listed in Box 5-1, achieving resource efficiency requires action on a number of fronts at a number of different levels. At the core of understanding the potential benefits of resource efficiency is the recognition that, in their journey through the economy, materials have value added to them and become resources and products. However, they can also lose value, as resources and products become 'wastes', which may be seen from an economic perspective as materials with negative value. Traditionally, the waste management industry adds value to wastes (e.g. by separating, transporting, or recycling them). However, as

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far as the economy as a whole is concerned, this adding value from waste management represents a cost. The key to increasing resource efficiency is to intervene in materials' journey from resources to wastes by preventing or delaying their loss of value. There are a number of now well understood means of achieving this, a number of which have already been mentioned in the EREP Action for Resource Efficiency mentioned in Box 5-1:

- Reduce the quantity of materials required to deliver a particular service (lightweighting)
- Increase the time material products deliver their service before becoming wastes (product durability)
- Reduce the use of energy and materials required both to produce a product and in its use phase (efficiency)
- Reduce the use of materials that are hazardous or difficult to recycle or dispose of (substitution)
- Make it easier to recycle materials by differentiating between wastes and recyclables (by-products)
- Create markets for recycled materials through product specifications and green public procurement (standards and regulation)
- Design products that are easier to recycle (eco-design)
- Incentivise waste reduction and high-quality separation by consumers (e.g. variable waste charging, or pay as you throw)
- Incentivise separation and collection systems that minimise the costs of recycling and re-use (e.g. deposit-refund schemes)
- Facilitate industrial clusters that exchange materials while they are still resources to prevent them from becoming wastes (industrial symbiosis)

There now follow brief descriptions of the key characteristics of some of these resource efficiency measures and approaches.

Lightweighting involves producing a product with the same performance characteristics that is lighter in weight. The most common applications occur in vehicle manufacture, where lighter vehicles lead to greater fuel efficiency, and packaging, where savings can be made in the

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Environmental Product Declarations (EPDs) use Life Cycle Analysis to provide verifiable information of the environmental impacts of a product over its lifecycle, such as raw material

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Eco-design , also known as Design for the Environment, entails the systematic integration of environmental considerations into the design of products and processes with the aim of reducing their life cycle environmental impacts. Although design itself accounts for only about 15% of the resources of the manufacturing processes, the European Commission estimates that more than 80% of the life-cycle environmental impact of a product is typically determined at the design stage, and it has been estimated that by 2020, the first Ecodesign Regulations on 13 product groups could help to achieve energy savings equivalent to more than 12% of the electricity consumption of the EU in 2009 (compared to a 'business as usual' scenario)[236].

Industrial symbiosis (IS) comprises networks of companies operating in different sectors of activity that engage in mutually beneficial transactions of residuals, energy and other by-products to find innovative ways to source inputs and optimize the value of the residues of their processes[237]. Kalundborg (Denmark) is considered the paradigmatic model of a geographically specific IS network[238]. Operating industrial symbiosis networks have proven successful not only in diverting waste from landfill and reducing CO

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	Actual 5-year total[1]	Cumulative over 5 years[2]	Value for money (Public investment/ unit output)[3]
Environmental benefits			
Landfill diverted (mt)	7.0	12.6	0.44 (£/t)
CO_2 reduction (mt)	6.0	10.8	0.51 (£/t)
Virgin materials saved (mt)	9.7	17.5	0.32 (£/t)
Hazardous materials reduced (mt)	0.36	0.7	7.9 (£/t)
Water saved (mt)	9.6	17.2	0.32 (£/t)
Economic benefits			
Extra sales (£m)	176	317	0.087 (£/£)
Costs saved (£m)	156	281	0.099 (£/£)
Extra Government revenue (£m)		89	0.31 (£/£)
		Fiscal multiplier: 3.2 (£/£)	
Private investment (£m)	131		
Jobs created	3683		
Jobs saved	5087		

1 Total over 5 years, computed by simply summing the results for each year (independently verified)

2 Total over 5 years assuming NISP contribution to savings of only 60%, but persistence of savings to subsequent years, declining by 20% per year

3 Public investment of £27.7m over five years. For environmental categories, this is assumed to be split equally between 5 categories (i.e. £5.5m per category), divided by results in Cumulative column; for economic categories, the full public investment figure (i.e. £27.7m) is used as the numerator

Figure 30: Environmental and economic benefits from NISP, April 2005-March 2010. Source: Author calculation from data in NISP 2009[239], p.5.

239 NISP (National Industrial Symbiosis Programme) 2009 The Pathway to a Low Carbon Sustainable Economy, NISP, Birmingham

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These outcomes were the result of a sophisticated business-led, but publicly facilitated and funded, programme, which combined an innovative, networked IT system, an emphasis on innovation which involved close collaboration with the relevant Knowledge Transfer Network of the Technology Strategy Board, a strategic focus and delivery plan at the regional level, at the time coordinated though the Regional Development Agencies, and a relationship with the regulator, the Environment Agency, that not only gave access to information about the nature and location of materials that could be turned from wastes to resources but also was extremely helpful in clarifying the relevant regulations to businesses.

It was on the basis of these sorts of insights and results that the European Resource Efficiency Platform (EREP) recommended that industrial symbiosis should be facilitated at an EU level, as noted above. A recent study estimated that scaling up IS programmes across the EU could

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information and funding innovation, but four of them only apply to waste electrical and electronic equipment (WEEE) and all of them are so tentative that they will do little to help UK business to cope with resource risks, or grasp resource opportunities, in the relevant time frame.

The UK policy mix, shared according to the respective competences of the UK and devolved governments, should comprise:

- Economic instruments , including maintenance of the landfill tax; year-on-year increase in the aggregates tax; introduction of other resource taxes (see the next section); incentives for energy efficiency in buildings (e.g. Council Tax or Stamp Duty rebates); variable waste charging for households; and deposit-refund schemes
- Regulations to ensure only the incineration of non-recyclables, and for energy efficiency in buildings subject to extension or renovation
- Public facilitation of industrial symbiosis
- Continuing review through WRAP and the Environment Agency of waste definitions and product specification
- Intensification of Green Public Procurement .

At the EU level the UK Government should support, and contribute to the development of, policies for:

- More ambitious harmonisation at EU level of environmental taxes , through revision of the Energy Tax Directive, and the calibration of taxes on energy into both energy and carbon components (see next section)
- Intensification of extended producer responsibility , including product passports
- Regulations on waste exports , especially of electrical and electronic equipment
- More ambitious European action oneco-design

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Table 1: Confirmed and indicative rates for carbon price support (CPS).

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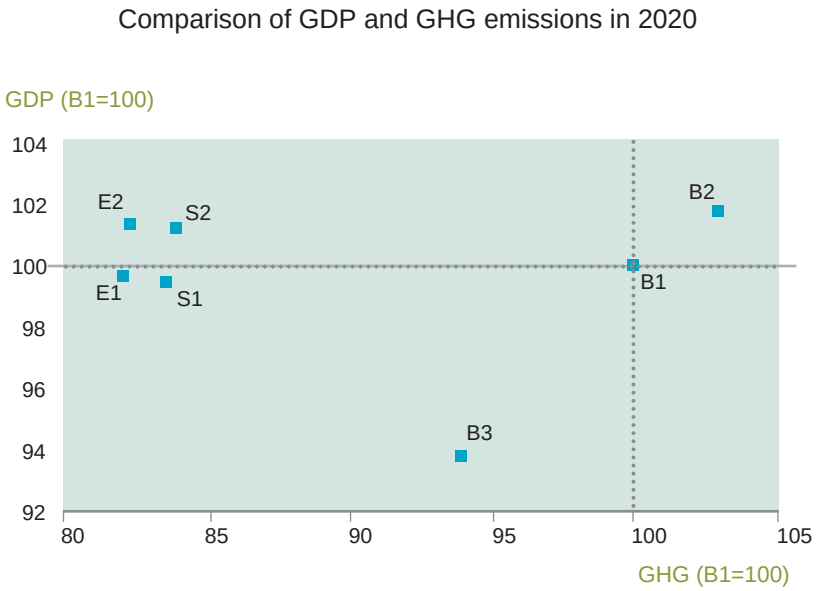

Figure 31: GDP and GHG emission outcomes from various scenarios of environmental tax reform in the UK. Source: Ekins et al. 2011, Figure 20, p.473.

Note(s):
GHG figures have been calculated on a net carbon account basis in $MtCO_2e$

Key to scenarios:
B1 is baseline with medium energy price trajectory
B2 is baseline with low energy price trajectory
S1 is ETR scenario with medium energy price, to be compared with B1
B3 is baseline with high energy-price trajectory, to give same end-user energy prices as S1
S2 is ETR scenario with low energy prices, to give same end-user energy prices as S1, to be compared with B2
E1, E2 are the same as S1 and S2, except that 10% of the revenues from the tax increases are recycled through investment in energy efficiency and renewables, rather than reductions in other taxes

The ETR outcomes, moreover, do not take account of any possible innovation effects or UK developments of low-carbon technologies, and their export, which might be expected as a result of the higher carbon/energy prices. Were these to occur on any scale, it is likely that the ETR scenarios would have higher GDPs than their respective baselines.

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In 2010 the Coalition Agreement committed the new UK Government to increasing the share of environmental taxes in total tax revenues over its lifetime. However, the Government then redefined the term ‘environmental tax’, despite there being a long-standing and widely agreed international definition as shown in Box 6-1. It seems curious, to say the least, that the Treasury should now be working to a different definition of environmental taxes to that of the ONS, which is following international conventions. The Institute for Fiscal Studies (IFS) found that under the Government’s definition it is likely that its target commitment on the share of environmental taxes in total tax revenues will be easily met, whereas it would not be under the ONS’s definition or under that proposed by the IFS itself, which includes company car taxes but excludes VAT on fuel duties, on the grounds that VAT is a general consumption tax.

Box 6-1: Definitions of Environmental Taxes

UK Treasury
Environmental taxes must meet the following three principles:

1. The tax is explicitly linked to the Government’s environmental objectives
2. The primary objective of the tax is to encourage environmentally positive behaviour change

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	HM Treasury	ONS	IFS
Aggregrates levy	•	•	•
Air passenger duty		•	•
Carbon reduction commitment	•		•
Climate change levy (i/c carbon price floor)	•	•	•
Company car taxes			•
EU emissions trading scheme auctions	•		•
Fuel duties		•	•
Landfill tax	•	•	•
Renewables obligation		•	•
VAT on fuel duties		•	
Vehicle excise duty		•	•
2010/11 revenue, £bn (% of total)	2.1 (0.4%)	42.8 (7.8%)	40.2 (7.3%)
2015/16 forecast revenue, £bn (% of total)	5.8 (0.9%)	47.4 (7.1%)	46.9 (7.0%)
Target met?	Yes	No	No

Table 2: Three definitions of 'environmental taxes', and compliance with target. Source: IFS 2012[248]

Note: Figures for 2010/11 are out-turns and 2015/16 are forecasts. Revenues are taken from the OBR Economic and Fiscal Outlook, consistent with the December 2012 Autumn Statement. The exception is company car taxes, where forecasts are taken from a written ministerial statement to the House of Commons on 16 July by Economic Secretary to the Treasury, Chloe Smith.

IFS analysis shows that the reason for the difference in the outcome in relation to the target is almost entirely due to fuel duty being excluded from the Treasury, but included in the ONS and IFS, definitions: because of cancellations in planned increases and deferred inflation adjustments, the revenue from fuel duty is set to fall by 0.8 percentage points by 2015-16. Seeking to meet Government commitments by abandoning internationally agreed definitions is not a way to enhance the credibility of Government policy.

248 IFS (Institute for Fiscal Studies) (2012) 'A defining issue? The government's pledge to raise the share of revenue from green taxes', http://www.ifs.org.uk/publications/6491

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Policy recommendations arising out of this macroeconomic analysis are as follows:

- The Government should set up an official Fiscal Commission for a Green Economy , along the lines of those established in a number of other countries[249] to explore the implications of a wide range of possible environmental and resource taxes. Some of the issues that could be explored by the Commission are set out in box 6-2.

- In addition to supporting reform of the EU ETS to reduce the number of permits, the UK Government should press the EU to adopt a CPF at EU level , as part of the ongoing discussions of the Energy Tax Directive. This would increase the bargaining power of the UK and Europe in respect of border tax adjustments (see next proposal).

- In order to encourage the main international emitters of greenhouse gases outside the EU to adopt their own carbon pricing policies, preferably through international treaty , Europe should establish a system of international border tax arrangements, so that countries that do not adopt an internationally comparable carbon pricing system pay for their carbon emissions through tariffs. There is scope within WTO rules to support such adjustments, and the UK and Europe should stake out an aggressive negotiating position on WTO rules to ensure that these adjustments can be put in place, with a mechanism to compensate developing countries that lose out from the move to higher carbon prices.

- With a schedule for border tax adjustments in place, the UK should campaign for 100%

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Box 6-2: Issues for detailed exploration by a Fiscal Commission for a Green Economy

- Possibilities for and implications of the introduction of progressively increasing environmental and resource taxes on a broad range of materials, to enhance secondary uses of materials and take account of their pollution impacts, thereby increasing resource efficiency and resource security and improving environmental quality. The experience of the landfill tax should be extensively studied in this context.
- Introduction of National Road Pricing along the lines proposed in the Eddington 2006 report, which found that road pricing could reduce congestion by 50% by 2025 and generate annual welfare benefits of £28 billion per year[251]. The technology is now available to implement such a scheme.
- Coordination of vehicle fuel taxes and vehicle excise duty with road pricing.
- Reform of air passenger duty to a charge on a per plane basis, rather than per passenger, and to take account of other externalities of aviation including noise and other pollution emissions (including its enhanced radiative forcing).

Using resource and environmental taxation to move towards a green economy has huge benefits for efficiency both now and dynamically in the future. It gives producers the incentive to substitute and innovate toward resource-efficient and low-carbon technologies and it encourages them to choose the lowest-cost methods of reducing emissions and increasing resource efficiency. It does not require regulators to have comprehensive access to all information about carbon abatement costs. It also gives signals about the desirability of green innovation right across the economy.

6.2 Bolstering credibility in long-term policy direction

Expectations play a crucial role in influencing investor behaviour, and establishing credibility takes time, so it is critical that policymakers think carefully about policy design. In a rapidly changing economic environment, policymakers must embrace uncertainty on a number of fronts; for example technology costs, tastes and preferences, resource depletion rates and climate science,

251 Eddington, R. 2006 The Eddington Transport Study: the case for action, December, HMSO, Norwich, http://webarchive.nationalarchives.gov.uk/20090104005813/http:/www.dft.gov.uk/about/strategy/transportstrategy/eddingtonstudy/

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to name a few. So policy must be sufficiently stringent to change behaviour, predictable in order to contain policy risk, yet simple and flexible in evolving to changing circumstances while limiting compliance costs[252]. This requires that it be based on clear rules for review and revision, where the public sector responds to surprises in a predictable manner. Most importantly, stable rules that are not changed retroactively are a necessary condition in order to provide an appropriate risk-adjusted return to induce private capital to flow into high-risk technological sectors. The Government must convince businesses that it will not renege on its commitments once investment costs are sunk.

An appropriate analogue might be monetary policy. Interest rates are the main instrument for monetary policy. The main target is inflation. The private sector would prefer interest rate certainty, but economic news pertinent to inflation forecasts will evolve in unpredictable ways and interest rates will need to adjust to reflect this. Monetary authorities aim to minimise policy risk by making their activities as open and predictable as possible. In the UK, this has taken the form of publicly announcing the inflation target and timeframe, preannouncing the dates of regular monthly meetings to assess interest changes, identifying the members of the committee responsible for making those changes, publishing the minutes of these meetings and the votes of the members and publishing regular internal inflation forecasts. This way, surprises to investors are kept to a minimum and a predictable and stable response is more likely. The risks investors face apply to unknown developments in the economy and not unknown responses by the monetary authorities. As Mervyn King once put it'A reputation for being boring is an advantage - credibility of the policy framework helps to dampen the movement of the see-saw. If love is never having to say sorry, then stability is never having to be exciting[253].'

The fact is that technologies, institutions and scientific findings will evolve in often unexpected ways and policy must adapt to reflect this. The private sector expects to take on market risks, but policy risk can be minimised through clearly understood, flexible and transparent policy frameworks. Recent examples of sudden or even retrospective changes to feed-in tariffs, in the UK and Spain respectively, run exactly counter to this principle, in which perceived policy risk is understood to be an important real cost to the economy that government can reduce. Clear procedures, with well-articulated objectives and decision criteria, are important in enabling confidence. For example, a pre-announced mechanism for periodic review of feed-in tariffs to account for the evolution of technology costs could lower investment costs by reducing the perceived risk that sudden changes to tariffs might occur.

252 Hepburn, 2010 'Environmental policy, government, and the market' Oxford Review of Economic Policy. See also Helm, D. (2010) Government failure, rent-seeking, and capture: the design of climate change policy. Oxford Review of Economic Policy, 26(2), 182–196.
253 Balancing the Economic See-Saw - Speech by Mervyn King, Deputy Governor Bank of England, 14 April, 2000

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The 1990s saw very public wrangling over the responsibility of energy regulators for achieving environmental targets, with gas regulator Ofgas effectively blocking a range of energy efficiency programmes, the costs of which would have been passed on to consumers. Over time, the importance of environmental objectives have become more firmly embedded within regulator mandates. Ofgem's duty to contribute to sustainable development was introduced in 2004, and was further promoted in the Energy Act 2008. This Act clarified that the foremost duty of Ofgem – the protection of consumer interests – applied to future as well as present consumers. This enables Ofgem to explicitly consider the costs and benefits of action in the long term, taking into account inter-generational equity rather than focusing only on today's consumers.

These changes have enabled a gradual shift from a position in which the regulator acted to block environmental policies, to one in which the regulator plays an active role in delivering a greening of the UK energy system. The slow nature of this process illustrates that the independence of regulators and similar bodies can create inertia in shifting the goals of policy. This inertia can be an advantage when long-term credibility is crucial. Embedding green objectives in institutional mandates is thus an important part of a green economy strategy that is credible in the long-term.

6.3 Confidence in Governments' Policies – Index-Linked Policy Performance Bonds

The Long Finance London Accord community has developed a simple, almost subversive, proposal for many sustainable government policies – index-linked policy performance bonds [255]. These are bonds that commit governments financially, and through that commitment provide a hedge that brings in investment. One important example on climate change finance would be index-linked carbon bonds. An index-linked carbon bond is a government-issued bond where interest payments are linked to levels of a carbon target – for example, levels of feed-in tariffs for renewable energy, or actual greenhouse gas emissions of the issuing country [256]. An investor in an index-linked carbon bond receives an excess return if the issuing country's targets are not met,

255 Onstwedder and Mainelli (2010) 'Living Up To Their Promises' Environmental Finance, Fulton Publishing, February 2010, p.17; Mainelli and Onstwedder (2009), 'Over The Hedge – Index Linked Carbon Bonds', Petroleum Review, Energy Institute (November 2009), page 16; Mainelli, Onstwedder, Parker, and Fischer (2009), 'Index-linked Carbon Bonds – Gilty Green Government', Z/Yen Group Ltd.

256 The City of London put forward the idea in its 2009 Copenhagen submission – http://www.longfinance.net/la-reports/index.php?option=com_content&view=article&id=182&Itemid=157

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Table 3: Daily United States Treasury yield curve rates
Source: United States Treasury

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reasons. Policies to encourage low-carbon investment would provide new business opportunities and generate income for investors precisely because they address growing global resource challenges.

Indeed, it is because resource-efficient investment is so transformational in scale that a credible public strategy can create profitable new markets attractive to private investors. The key issue is how the public sector can build credibility sufficient to galvanise private investment, when private investors are well aware of the risk of time-inconsistent behaviour by governments. But it is worth noting that one of the advantages of green measures, at a time of stretched public funds, is that such a stimulus would be expected to come predominantly from the private sector, requiring minimal additional public spending or borrowing. Indeed policies such as carbon and resource pricing and the pricing of other socially harmful activities can raise revenues for the public sector, while standards and regulations can be expected to be fiscally neutral in the short run.

Apart from their limited call on the public purse, many green projects also have other desirable stimulus properties which make them suitable for consideration as part of an economic recovery plan. The short-term macroeconomic merit of an investment in terms of what constitutes a good economic stimulus – whether private or public sector driven – can be judged against established criteria[260]. These include tests on whether an investment is timely, temporary and targeted.

Firstly, the criterion of *timeliness* reflects the need for fiscal policy to be *counter-cyclical*: if spending is delayed, then it may inadvertently have the exact opposite effect to that intended, fuelling an unsustainable cyclical upturn. For infrastructure spending in particular, timeliness may be difficult to achieve due to the occasional long lead times in project development and multi-year construction schedules. However, while more immediate means of injecting cash into the economy do exist – for instance, through tax cuts or cash hand-outs, as, for instance, used by Australia in the early stages of the Global Financial Crisis in 2009[261] – these are also problematic: it is likely that direct transfers will lead to a lower increase in spending and greater cash hoarding than spending channelled through infrastructure projects. Nevertheless, important considerations include how long a project takes to get off the ground from scratch, including development and approval time, and how many projects are 'shovel-ready'. Consequently, it is important that policy makers move quickly.

The second key criterion for stimulus is that a measure is *temporary*. This reflects not only the understandable public sector desire to limit public spending obligations, but the broader and

260 A discussion of the use of fiscal policy as a tool for macroeconomic management in a demand-deficient environment can be found in Bowen & Stern (2010) and also Fankhauser, Stern, Zenghelis, & Bowen, 2009.
261 Leigh, A. (2009). 'How Much Did the 2009 Fiscal Stimulus Boost Spending? Evidence from a Household Survey.' Australian National University.

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more relevant macroeconomic desire not to 'crowd out' alternative productive investment when the economy is operating close to capacity. The latter applies to both public and private investment[262]. Many green infrastructure investments involve a large up-front capital cost and lower running costs than conventional alternatives, precisely because they are designed to be more resource efficient. Naturally, green infrastructure spending typically involves some degree of upkeep costs, though these may be relatively low compared to capital expenditure costs.

Yet concerns about timeliness and temporariness can be overstated. Most current estimates of developed world output gaps[263] suggest that resources will continue to be underutilised for at least the next half decade in many developed economies[264]. Moreover, the confidence impact associated with a clear strategy to encourage investment is likely to outweigh excess concerns about the stimulus contribution of every individual project. In other words, the sum of an ambitious investment programme is greater than the individual parts. Indeed, had commentators and policymakers spent less time worrying over the last four years about the 'shovel-readiness' of projects, and more time actively driving investment, economic out-turns in 2012 and 2013 might have been better than they were.

There are, of course, many competing demands for public investment. Public spending on nurses and teachers should augment human capital and also boost long-run growth. But, as already noted, the call on public funds is likely to be lower for many green policies. In addition, the emerging new threats and challenges suggest the infrastructural under-provision in the green sector is greater than in many traditional investment sectors. The gap between what is being done and what needs to be done is arguably larger.

The third criterion for an effective stimulus is that the additional private or public spending is appropriately targeted at areas where the investment will have maximum benefits in terms of its multiplier effect. Calculating the relevant multipliers is not straightforward: there are methodological issues related to time frame (short-term versus long-term multipliers) and coverage (sector versus project multipliers), as well as difficulties in obtaining sufficiently detailed data. It is important also to recognise that long-run investment multipliers can be expected to be significantly smaller than those which apply in a demand-deficient environment.

There are a wide range of estimates of fiscal multipliers in the empirical literature. Freedman et al. (2009) noted that the multiplier is likely to vary according to the type of fiscal action[265]. Government infrastructure spending is likely to have a bigger multiplier than a tax cut if

262 Policymakers would, in fact, want to actively crowd out some non-green investment, even in the long run, in order to attain green growth objectives. More generally, Baxter & King (1993)showed how productive public investment can enhance the productivity of private investment and significantly increase the long-run government spending multiplier.
263 OECD 2013. OECD Economic Outlook. Annex table 10.
264 Defined as the period over which actual output is below the economy's non-inflationary potential.
265 Freedman, C., Kumhof, M., Laxton, D., and Lee, J. (2009), 'The Case for Global Fiscal Stimulus', IMF Staff Position Note 09/03, 03 March.

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households save a portion of their extra income. Tax cuts or spending increases aimed at poorer households are likely to have a larger impact on spending than ones targeting the rich, as lower-income households tend to spend a higher share of their income. Multipliers also tend to be higher for more closed economies, where extra spending is less likely to leak into imports[266].

The size of the multiplier also varies according to economic conditions. For an economy operating at full capacity, the fiscal or investment spending multiplier would be expected to approximate to zero. Since there are no spare resources, any increase in government (or any other) demand for a sector's output would serve to displace output elsewhere. Hiring labour would be expected to push up wages in a tight market which crowds out employment elsewhere, while additional investment would be expected to raise real interest rates which crowds out alternative investment. But in a recession, with underutilised resources, a spending boost can increase overall demand. In such an environment the confidence effect is likely to 'crowd in' private investment.

But if fiscal sustainability is seen as under threat by policy action, interest rates on bonds could rise in response to government borrowing. Moreover, if consumers expect higher future tax demands to finance today's additional government borrowing, or lower productivity as a result of the government action, they could spend less today and save more. These factors would all lower the fiscal multiplier. The response of the monetary authorities also needs consideration – if additional spending is seen to raise inflationary pressure, policy rates might be pushed higher in order to offset the fiscal stimulus.

The likelihood of such responses is limited when spending is held back because of lack of confidence about demand, rather than because of concerns about balance sheets. In an environment (such as the present) where policy rates are close to the zero bound, the assumption that monetary authorities will actively offset a fiscal stimulus seems unfounded. Christiano et al. argue that, whenever the zero bound on nominal interest rates is binding, the government spending multiplier is much bigger than one[267]. Using U.S. data, Auerbach and Gorodnichenko (2012) found that fiscal multipliers associated with government spending fluctuate from near zero when the economy is operating close to capacity to about 2.5 during recessions[268].

In short, making accurate assessments of multipliers for specific spending sectors is likely to be of limited value. But preliminary estimates of the likely first-round multiplier effects of different projects can be assessed on the basis of key parameters. Projects with limited import content,

266 Ethan Ilzetzki, Enrique Mendoza and Carlos Vegh (2010) 'How big (small) are fiscal multipliers?' http://econweb.umd.edu/~vegh/papers/multipliers.pdf. See also Kaminsky, Graciela, Carmen Reinhart, and Carlos Vegh, (2004) 'When it rains, it pours: Pro-cyclical capital flows and macroeconomic policies,' NBER Macroeconomics Annual which shows evidence that capital flows and fiscal policy tend to be pro-cyclical, exacerbating economic cycles.
267 Lawrence Christiano, Martin Eichenbaum and Sergio Rebelo (2009) 'When is the Government Spending Multiplier Large?' LSE http://cep.lse.ac.uk/seminarpapers/09-06-09-EIC.pdf. Almunia, Miguel, Agustin Benetrix, Barry Eichengreen, Kevin O'Rourke, and Gisela Rua (2010), 'From Great Depression to Great Credit Crisis: Similarities, Differences and Lessons,' Economic Policy, Vol. 25, have concluded that fiscal multipliers were about 1.6.
268 Auerbach & Yuriy Gorodnichenko, 2012. 'Fiscal Multipliers in Recession and Expansion,' NBER

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Conclusions

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Conclusions

Conclusions

- Appropriate Government intervention across the innovation chain , supporting the science base, start-ups that begin the process of bringing inventions to market, and deployment that helps these start-ups across the ‘valley of death’ and become profitable businesses.

- A process of infrastructure assessment that can distinguish between those forms of infrastructure that are essential for a green economy and those that are not, or are positively inimical to it, combined with a combination of public spending through new financial institutions and leverage of private investment that will deploy new green infrastructure at scale.

- Environmental tax reform which systematically increases the price of carbon-based energy and other environmental resources associated with negative impacts, and which uses the revenues to offset distributional impacts, incentivise further investments in resource efficiency or reduce other taxes which fall on labour or entrepreneurial success. Such gradual and predictable price increases, and the more efficient resource use to

About the UCL Green Economy Policy Commission

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UCL Policy Commissions are an initiative under the UCL Public Policy Strategy. They are a way of bringing together academics and researchers across disciplines to consider issues of considerable public policy importance and to attempt to address these by consolidating and synthesising knowledge and expertise. They aim to deliver novel insights derived from cross-disciplinary collaboration and to make policy recommendations on the basis of these.

The UCL Green Economy Policy Commission ran from September 2012 to December 2013 and consisted of a core group together with other members and advisers. It operated through regular core group meetings; occasional wider discussion; and a programme of stakeholder engagement through the convening of meetings with business representatives, civil servants and politicians whose views were sought in response to the ideas and proposals of the GEPC. The findings of the UCL GEPC were also presented in fringe meetings at the three party conferences in 2013, and the discussions there informed the report. The final report was written by a subset of the core group and reviewed by all Commission members.

UCL Public Policy

UCL believes that as a leading university, we have an obligation to ensure that our knowledge and expertise informs the development of public policy. UCL Public Policy is an initiative based in the Office of the Vice-Provost (Research) which seeks to bring UCL's academic expertise to bear on pressing public policy challenges by integrating knowledge and evidence from across disciplines to inform policy. It provides an interface for researchers and policy-makers, facilitates routes for engagement between research and public policy, supports the translation of research into policy-focused outputs, and promotes dialogue and debate on key public policy questions.