:vivideconomics

The Green Investment Bank: Policy and Finance Context

Report prepared for the Department for Business Innovation and Skills

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Overview

This report sets out the policy and finance context for the Green Investment Bank (GIB)[1]. It makes the high-level case for GIB intervention along Market Economy Investor Principles (MEIP). The main conclusions are as follows:

- The GIB is part of a broader UK ambition to create a low-carbon, climate-resilient and environmentally sustainable ('green') economy. This goal is shared at an EU level and many of the UK's targets are based on existing EU directives, e.g. on greenhouse gas emissions, water, waste, transport, climate change and renewable energy. At the core of UK plans is a statutory commitment to reduce greenhouse gas emissions by 50% in 2027 and by at least 80% in 2050.

- The GIB is one of several policy measures taken by the government to create a green UK economy. Each measure is aimed at a particular aspect of the green growth challenge, for example by putting a price on carbon, supporting new technologies, internalising local externalities, overcoming behavioural barriers, and addressing information imperfections. The GIB will complement and strengthen these measures by increasing investor confidence and facilitating access to finance.

- This combination of measures, of which the GIB is a central part, is necessary to unlock the levels of green investment required. The transition to a green economy will require infrastructure investments (broadly defined) of £220 - 330 billion over the next decade (or £22-33 billion a year on average). This constitutes a step change compared with past investment trends. Firms in the green economy[2] currently raise up to £18 billion in new capital and invest maybe £6-8 billion in green projects a year.

- The finance to make these investments is available in principle. The UK as a whole dedicates well over £200 billion a year to investment (gross fixed capital formation). However, redirecting a large fraction of this capital to the green economy is not straightforward. There are barriers related to the risk profile of green investment, the risk appetite among investors, the capacity of borrowers to absorb additional finance and the availability of project finance skills.

- The experience of similar organisations suggests that the GIB could play an important role in unlocking finance and implementing the UK's green economy objectives**.** Organisations such as the European Investment Bank (EIB) and the World Bank already play such a role globally. Eighty-five percent of the EU's renewable energy investment is channelled through the EIB. Not all of their interventions are based on state aids. Most finance is provided on Market Economy Investor Principles (MEIP). Rather than crowding out private finance, these organisations mobilise additional private investment from banks, equity funds and other sources.

[1] Input from Slaughter & May is gratefully acknowledged.

[2] The correspondence between the sectors covered in this report and the green economy as a whole is only loose. We use the terms 'green infrastructure ' and 'green economy' interchangeably to describe the areas the GIB could potentially be active in: low-carbon energy, waste, water and rail. Energy efficiency is included wherever feasible. However, since there is no 'energy efficiency sector' it is not always possible to identify relevant investment trends.

These conclusions are derived in six sections:

- Section 1 outlines the UK government's **vision for a green economy**. It sets out the legal basis for pursuing that vision, in particular the 2008 Climate Change Act and relevant EU directives. It summarises briefly the international context to show how the UK's vision is shared internationally.
- Section 2 details **a possible investment and policy strategy** to meet the government's objectives. It draws on the analysis of government departments as well as independent non-departmental public bodies such as the Committee on Climate Change.
- Section 3 translates the strategy of section 2 into **financing needs**. It compares the required investments with the historical rate of capital accumulation in the green economy sectors and their ability to raise finance.
- Section 4 discusses **potential sources of additional capital**. It provides a high-level review of the main pools of capital that could be expected to finance more green investment, both in the UK and elsewhere, and discusses possible constraints.
- Section 5 takes a closer look at the UK electricity sector, which is central to building a green economy and investment needs are particularly high.
- Section 6 makes **the case for MEIP interventions** by the GIB. It recapitulates the general need for a step change in policy if green targets are to be met. It reviews precedents where the need for accelerated investment was met through a dedicated public institution.

1 The UK's vision for a green economy

This section provides the environmental, economic and policy context in which the GIB is considered. It explains that the move to a green economy is both a statutory obligation for the UK government, an environmental imperative and a commitment to Britain's European and international partners. The section starts by setting the European and global context before reviewing the UK's green economy objectives, related to climate, water, waste, transport and renewable energy.

1.1 The international context

The UK's vision for green growth is shared by many governments in the EU and beyond. At the 2011 Ministerial Council Meeting of the OECD, ministers agreed that '*green growth …can help expand economic growth and job creation through sustainable use of natural resources, efficiencies in the use of energy, and valuation of ecosystem services*' (OECD 2011). In France, the Grenelle de'l Environnement sets out measures and targets for the transition to a low-carbon economy. Germany has become a world leader on renewable energy. In Spain, the Sustainable Economy Act (approved in March 2011) sets a target of a minimum 20% of final energy consumption to be met from renewables. Among developing countries South Korea has made green growth the cornerstone of its economic recovery strategy, guided by its Five Year Plan for Green Growth, which identifies funding of more than US$80 billion (2% of GDP) to support the delivery of three strategies, ten policy directions and 50 core projects (UNEP, 2010a).

The UK's actions on climate change form part of an EU-wide drive for low-carbon prosperity. The EU is an international leader on climate change with a clear vision and stringent, EU-wide targets. The EU's Climate and Energy package of June 2009 (known as the "20-20-20 package") calls for:

- a 20% reduction in EU greenhouse gas emissions below 1990 levels, rising to 30% provided that other developed countries commit to comparable emission reductions under an international agreement. In order to help hit this target, the June 2009 Effort Sharing Decision, part of the 20-20-20 package, set legally binding individual national targets for reductions in greenhouse gas emissions (excluding emissions which are covered separately by the EU Emissions Trading Scheme), such targets to be met by 2020, compared with 2005 levels. The UK's target is a 16% reduction;
- a 20% share of renewable sources in EU energy consumption, achieved by the Renewable Energy Directive which sets legally binding targets (see section 1.2);
- a 20% reduction in primary energy use (by increasing energy efficiency) compared with projected levels. No binding targets have been laid down in legislation on energy end-use efficiency. The Energy Efficiency Directive sets indicative energy savings targets of 9% in the period 2008-2017. Whilst these targets are not binding, the UK is obliged to take cost-effective, practicable and reasonable measures designed to contribute towards achieving this target.

All three elements are to be achieved by 2020. The package also includes measures to strengthen the EU Emissions Trading Scheme (EU ETS), deal with emissions not covered by the EU ETS (such as transport, waste, buildings and agriculture) and promote carbon capture and storage (CCS).

Many other member states are translating EU obligations into national legislation. Besides the UK, member states that have passed (or are in the process of passing) climate change laws, including for example:

- *Austria*: climate change act passed at ministerial level in June 2011 and is awaiting Parliamentary approval, but the targets for 2020 are not defined yet;
- *France*: law resulting from the Grenelle de'l Environnement was passed in July 2009, it includes annual emissions targets, although there is no compliance mechanism;
- *Germany*: the Integrated Climate and Energy Programme of 2007 (updated 2008) sets a 40% emission reduction target for 2020, with measures on buildings, renewable energy and transport;
- *Ireland*: a climate law is expected to be passed in 2012;
- *Italy*: A comprehensive Climate Change Action Plan was agreed in 2007 to help the country comply with EU and Kyoto obligations;
- Discussions are on-going in Belgium, Denmark, Czech Republic, Finland, Hungary and Spain (where a regional climate law was passed in the Basque county).

Internationally, a growing number of countries have adopted climate change legislation. A recent survey of climate change legislation in 16 major economies, both industrialised and emerging[3], found that most of them (the USA being the only exception) had passed flagship laws on climate change similar to the UK's Climate Change Act, which contain (aspirational or statutory) targets and provide a unifying framework to tackle climate change. In total the survey found 155 laws covering climate change, renewable energy, energy efficiency, forestry or other relevant issues, or about 10 per country (Townshend et al. 2011). The survey paints a picture of increasing action on climate change at the national level, both in industrialised countries and emerging markets. Most of these activities are reflected in the pledges which countries have made under the Copenhagen Accord[4]. The Copenhagen Accord pledges of selected countries, all for emission cuts by the year 2020, are as follows[5]:

- *Australia*: 5% from 2000 unilaterally; 15-25% under a global agreement, depending on its ambition;
- *Canada*: 17% from 2005, to be aligned with US target;
- *European Union*: 20% from 1990, rising to 30% as part of an international agreement;
- *Japan*: 25% from 1990,premised on a fair and effective international framework;
- *USA*: 17% from 2005, 'in conformity with [then] anticipated ... [US energy and climate] legislation';
- *Brazil*: voluntary measures expected to yield a 36.1 – 38.9% reduction relative to business-as-usual;

[3] Besides the UK, the study covered the European Union, France, Germany, Italy, Canada, Japan, Mexico, USA, Brazil, China, India, Indonesia, Russia, South Africa and South Korea.

[4] The Kyoto Protocol is an international agreement which sets legally binding greenhouse gas emissions reduction targets on those parties included in Annex B to the Protocol. The Kyoto commitment period expires in 2012, and the Copenhagen Accord is part of the formal international process designed to try and reach an agreement on another legally binding commitment period under the Protocol. The Accord is a political declaration – it is not legally binding. When the UK set itself the targets contained within the Climate Change Act 2008, it was expected that the UK would be subject to binding international targets post-2012, and the UK is continuing to work with the EU to try and reach an international agreement imposing legally binding targets on its signatories.

[5] http://unfccc.int/meetings/cop_15/copenhagen_accord/items/5264.php

- *China:* 40 - 45% reduction in carbon intensity (carbon dioxide emissions per unit of GDP) – voluntary;
- *India*: 20 - 25% reduction in carbon intensity– voluntary;
- *Mexico*: 30% relative to business-as-usual – voluntary;
- *South Africa*: 34% relative to business-as-usual – voluntary;
- *South Korea*: 30% relative to business-as-usual – voluntary.

In the areas of water, transport and waste, the UK is similarly guided by EU regulations. The pertinent directives include the *Waste Framework Directive*, with binding targets on the re-use and recycling of waste (see sections 1.2, 2.5), the *Water Framework Directive*, which requires all groundwater and surface water to meet a 'good' environmental standard by 2015, the *Urban Waste Water Treatment Directive*, the *Bathing Water Directive* and, in the transport sector, EU targets on the carbon intensity of new cars and vans (see sections 1.2, 2.4).

The UK's environmental ambitions were explicitly set with this European and global context in mind. The 2050 target contained in the Climate Change Act was derived through an explicitly-global calculus that started with a global climate objective, worked out the ensuing global emissions constraint and suggested a fair burden sharing contribution by the UK (see Committee on Climate Change 2008). Consistency with both this global target and with EU policies was a core criteria (alongside technical and economic feasibility) in determining the appropriate carbon budgets for 2008-27 (Committee on Climate Change 2008, 2010a)[6]. Similarly the UK's renewable energy, energy efficiency, waste and water targets are directly driven by its commitments under the relevant EU directives, which will be detailed in section 1.2 and 2.

1.2 Decarbonisation and green growth in the UK

The UK government is committed to green growth and prosperity. Green growth can be defined as 'environmentally sustainable, biodiverse, low-carbon and climate-resilient growth in human prosperity' (Bowen and Fankhauser 2011).The successful transition to a green economy is an important ambition for the Government. Whilst recognising the significant short term costs of transition to a green economy, the government believes that, in the context of a global climate change agreement, a greener UK economy will relieve the environmental burden on future generations, allow UK businesses to benefit from new markets for environmental goods and services and create a more sustainable international economy:

> *'The transition to a green economy will bring a range of advantages. ... It can help UK business to manage risks, such as those from increasing and fluctuating fossil fuel prices, increasing resilience, such as to the impacts of climate change and seize the opportunities from new and emerging markets. ... Business across the whole economy can save money through increased energy- and resource-efficiency. A prosperous and thriving green economy will generate the investment,*

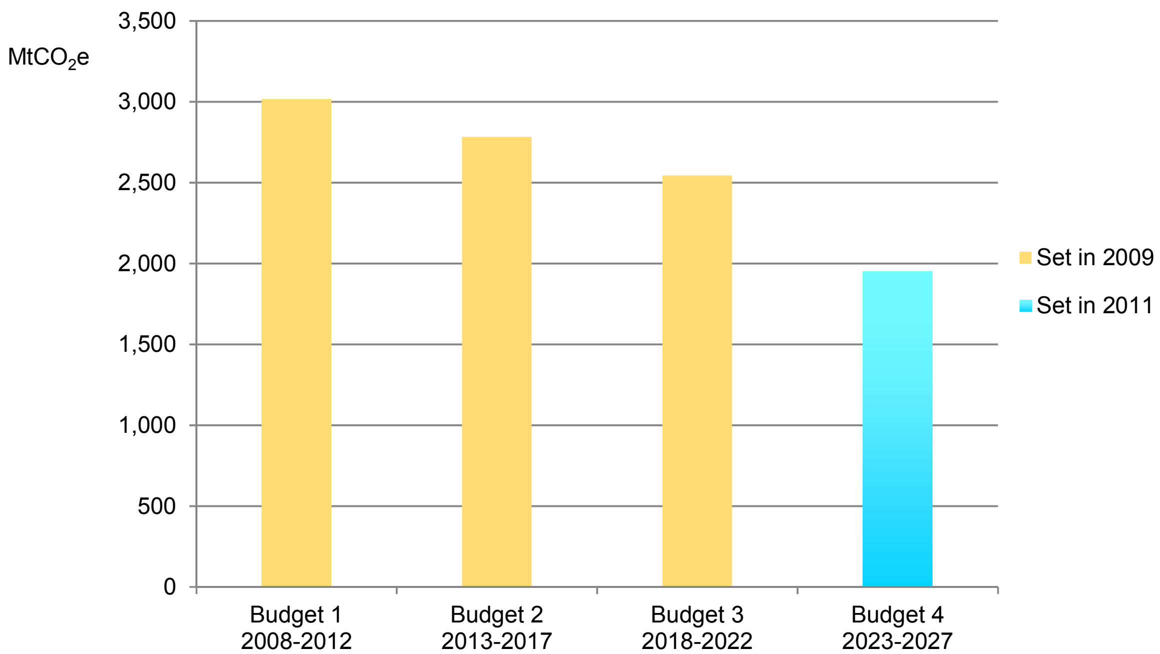
[6] Note that the fourth carbon budget (2023-27) assumes, and pushes for, a 30% EU-wide emission reduction target, consistent with the EU's offer under a global deal.

> *innovation, skills and entrepreneurship needed to transform our products and services, developing cleaner technologies and capturing new international markets'*.(HM Government 2011)

According to the same source, the costs of transition are thought to be 'significant but manageable', provided that the most efficient mix of interventions is chosen and a long-term policy framework is put in place to increase business certainty of payback from investment.

The cornerstone of the UK's green growth strategy is decarbonisation. The UK is subject to stringent, legally binding greenhouse gas targets imposed at UN, EU and domestic level. The 2008 Climate Change Act commits the UK to reduce its greenhouse gas emissions by at least 80% by 2050, relative to 1990. This long-term target is complemented by a series of near-term, five-year carbon budgets that also represent statutory obligations under the Act. The first three of these were set in 2009 and the fourth in 2011. Successively they cover the period 2008 – 27. The carbon budgets mandate that UK greenhouse gas emissions have to be reduced by 22% in 2012, 28% in 2017, 34% in 2022 and 50% in 2027, all relative to 1990 levels (see figure 1). The UK is obliged by statute to ensure that each carbon budget is set with a view to, among other things, complying with the UK's EU and international obligations. These targets are legally binding commitments on the UK, represented by the Secretary of State, that are subject to an annual review on progress by the independent Committee on Climate Change. Non-compliance may be challenged in court by any party.

Figure 1. **The UK carbon budgets aim at reducing emissions to less than 400 $MtCO_2e$ a year in 2027**



Note: *Emissions in the base year (1990) were about 800 $MtCO_2e$*

Source *Committee on Climate Change*

There are a number of other important environmental obligations and targets, in many cases imposed on the UK by EU legislation. Although the focus of the much of the debate has been on carbon budgets, the transition to a green economy is supported by a number of other important targets. They include:

- *Renewable energy:* Through the EU's *Renewable Energy Directive* the UK is committed to produce 15% of its energy needs from renewable sources by 2020, with interim targets of 4% for 2011-12, 5.4% by 2013-14, 7.5% by 2015-16 and 10.2% by 2017-18. The Directive also obliges the UK to ensure that 10% of its transport energy consumption comes from renewable sources by 2020. As required under the Directive, the Government outlined its approach for meeting the 2020 target in the UK Renewable Energy Strategy (RES)[7] and reiterated it in the Renewable Energy Roadmap of July 2011 (DECC, 2010c, 2011a);
- *Waste:* The UK has binding targets to reduce the amount of biodegradable municipal waste that is sent to landfill to 35% of 1995 levels by 2020 (imposed by the EU's *Landfill Waste Directive*), to recover at least 70% of construction and demolition waste, and to recycle at least 50% of household waste by 2020 (both imposed by the EU's *Waste Framework Directive*);
- *Road transport:* UK car and van manufacturers are subject to EU-wide targets, implemented by the *Passenger Car Regulation*[8] and the *Van Regulation*[9], to reduce the carbon intensity of new cars and vans to 95 grams of carbon dioxide per kilometre (g/km) and 147 g/km respectively by 2020;
- *Aviation:* The UK aviation industry is now subject to the EU Emissions Trading Scheme (EU ETS), which caps the total quantity of carbon allowances to be issued to EU aircraft operators to the equivalent of 97% of the average 2004-2006 emission levels during 2012, and to the equivalent of 95% of the average 2004-2006 emission levels during the period 2013-2020. The UK also announced in 2009 a domestic aim of returning aviation emissions to 2005 levels by 2050;
- *Rail*: There are no direct targets on rail, although the government has outlined its commitment to modernising and upgrading Britain's railway infrastructure and creating a sustainable transport system (as evidenced by projects such as Thameslink, Crossrail and high-speed rail);
- *Water consumption:* In its vision for 2030 the Department for the Environment, Food and Rural Affairs sets a target that water consumption in England[10] should fall to an average of 130 litres per person per day by 2030 (or possibly even 120 litres per day), from the current level of around 150 litres per person as well as achieving, *inter alia*, *'a sustainable supply-demand balance across England with no seriously water stressed areas'* and *'low levels of leakage, with targets set and met at the optimum balance of economic, environmental and other costs.'* (Defra, 2008);
- *Water supply:* Although no specific targets were derived, the Environment Agency (2008) concluded that action to reduce abstraction from sensitive environments may be needed by 2015 across England and Wales. On waste water, investments are being made to meet the requirements for the EU Urban

[7] Published and notified to the European Commission in July 2009

[8] Regulation (EC) No 443/2009

[9] Regulation (EU) No 510/2011

[10] Policy on water is devolved to the regional administrations.

Waste Water Treatment Directive – for example, Severn Trent Water has planned on spending £107m for the period 2010-2015 on controlling pollution;

- *Natural environment:* The UK is subject to international habitat protection obligations imposed at the UN-level under the Convention on Biological Diversity. In accordance with the Convention, the UK has published its Biodiversity Action Plan (UKBAP) which sets various targets on land restoration and expanding habitats to be achieved by 2015. The EU Habitats Directive also obliges the UK to protect certain natural habitats by adopting conservation measures and to select and propose Special Areas of Conservation. Proposals stemming from the 2009 UK Marine Bill to create over one hundred Marine Conservation Zones (MCZs) were unveiled in September 2011, albeit with the caveat that only a small percentage would be fully protected.

There is broad political and electoral support for this vision. The Climate Change Act was passed near-unanimously, as were the first four carbon budgets. For example, the fourth carbon budget, although hotly debated, was passed in the House of Commons in June 2011 with only two votes against and two abstentions. The 2010 Coalition agreement states that the parties '*agree to implement a full programme of measures to fulfil our joint ambitions for a low-carbon and eco-friendly economy*'. The proposals mentioned in the agreement explicitly include the formation of a Green Investment Bank.

2 A strategy for a green economy

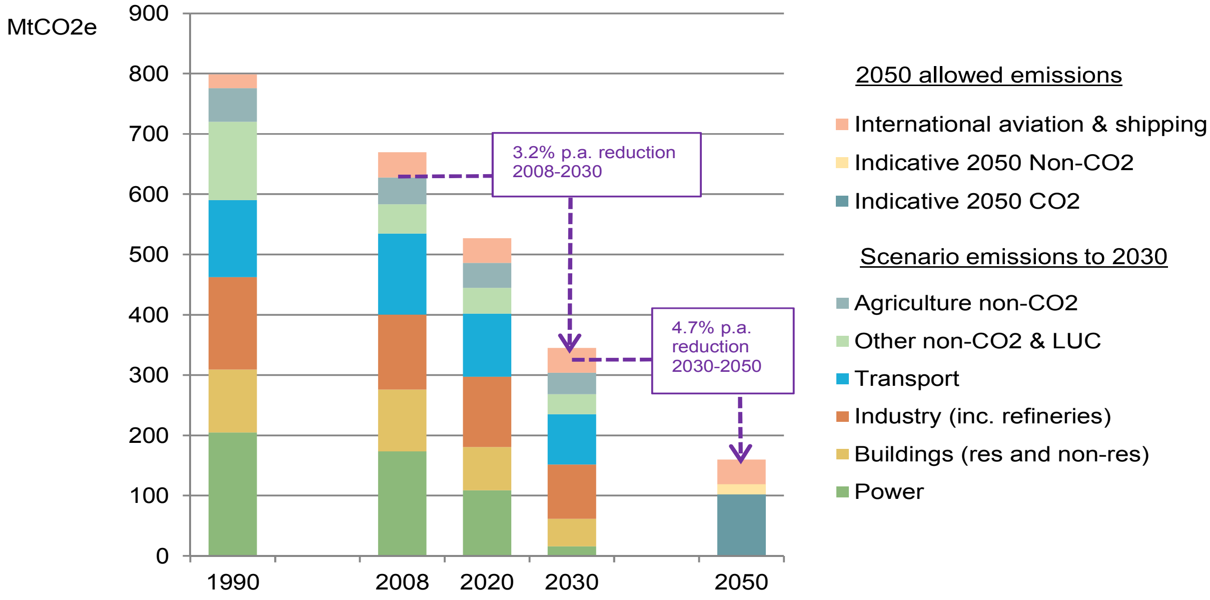
This section outlines an indicative investment and policy strategy to meet the government's green objectives. The strategy is set in a context where the transition to a green economy is a common European and international objective. The strategy demonstrates that the transition to a green economy, whilst imposing costs in the short term, is both technologically and economically feasible.

Sectors face a variety of challenges and will move at different speeds. Green investment is particularly urgent in the electricity sector, which needs to be virtually decarbonised over the next 20 years. Decarbonisation in buildings and industry is expected to move more slowly and is initially dominated by energy efficiency improvements and to some extent the development of renewable heat. Emission reductions in surface transport initially occur through efficiency improvements but within a decade or so might require new low-carbon technologies such as electric cars (see figure 2).Waste and water targets are driven by EU requirements.

The strategy is indicative and focuses on the main sectors in which a GIB role may be contemplated, although the Government's green economy objectives are wider. The strategy does not prescribe firm investment plans but illustrates a realistic possible way of meeting government objectives. The focus is on the next decade out to 2020.The information was taken from various official and independent sources, as follows:

- *Electricity*: derived from the monitoring framework of the Committee on Climate Change, complemented by information from the Department of Energy and Climate Change (DECC).
- *Buildings and industry:* derived from the energy efficiency and renewable heat targets of the Committee on Climate Change, complemented by the non-domestic energy efficiency datasets used in the GIB value for money work (Vivid Economics 2011).
- *Transport*: derived from data on electric charging infrastructure from the Committee on Climate Change and data on rolling stock and rail electrification from the Department for Transport.
- *Waste*: derived from Defra information, combined with calculations by Vivid Economics.
- *Water*: derived from Ofwat's Final Determinations on consumer prices and investment for the period 2010 - 2015, as well as the Strategic Direction Statements of the regulated water companies.

Figure 2. **Sectors face a variety of challenges and will decarbonise at different speeds**



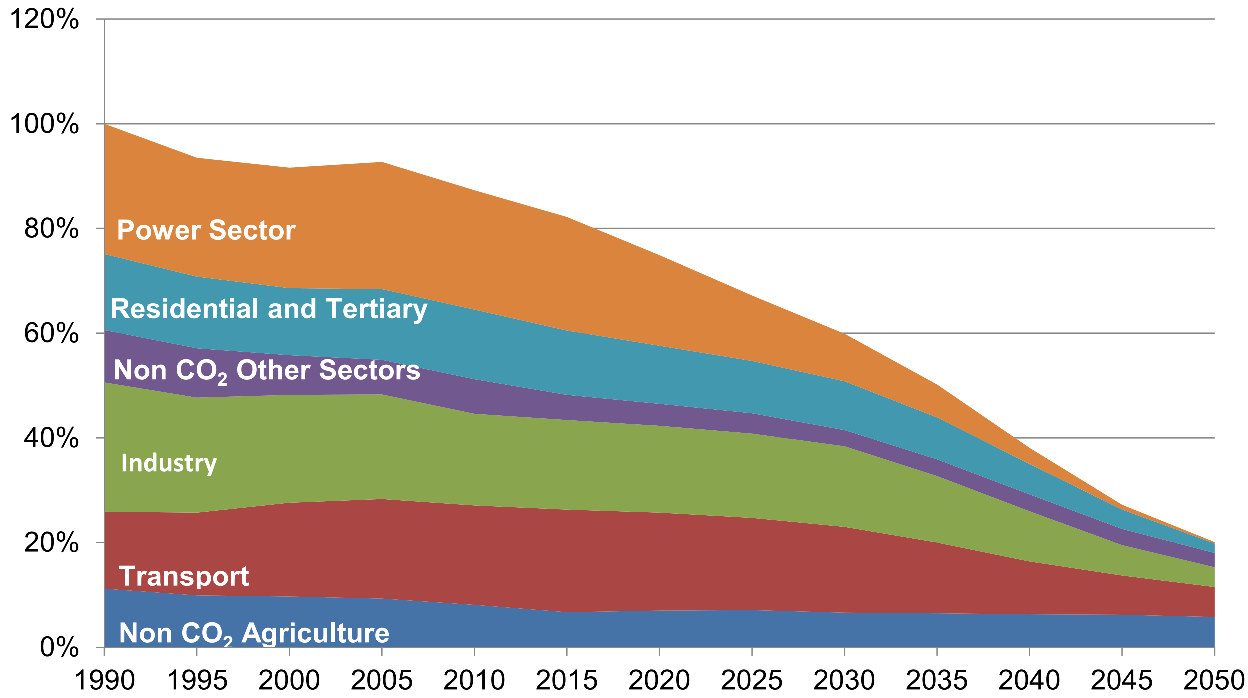
Source: Committee on Climate Change

2.1 The international context

The UK's decarbonisation plan out to 2020 has been developed in line with the EU's low-carbon roadmap. In March 2011 the European Commission published its roadmap for EU-wide decarbonisation out to 2050 (EC 2011a). The UK plan is motivated by and consistent with this roadmap. Both the EU and UK plan to work towards the same long-term target: an emissions cut of at least 80% by 2050 (80-95% in the case of the EU). In the short term, both plans rely on the same EU targets for renewable energy, energy efficiency, fuel efficiency and the emissions cap for the EU ETS. Both plans also have in common that they need a step up in policy to ensure delivery. The EU roadmap is depicted in figure 3.

After 2020, the UK roadmap is more ambitious than that of the EU, particularly in the power sector, where the UK needs large replacement investments in the 2020s. From the 2020s the emissions pathways of the UK and the EU begin to deviate. While the UK envisages a 50% cut by 2027, rising to 60% by 2030 (CCC 2010a and figure 1), the European Commission aims for 60% only by 2050.The Commission's 2030 target is 40%. A large part of the disparity can be explained by differences in the electricity sector. Much of the UK's current power generation capacity is due for replacement in the 2020s, which makes it possible (and indeed necessary to avid a high-carbon lock in) to accelerate power sector decarbonisation in the 2020s.

Figure 3. **The EU low-carbon roadmap envisages an 80% reduction in emissions by 2050**



Note: *1990 = 100*

Source *European Commission (2011a)*

Internationally, greenhouse gas emissions will have to peak within 10 years if global climate targets are to be met. The objective of the international climate diplomacy, endorsed by both the UK and the EU, is to limit the increase in global mean temperatures to no more than 2°C (relative to preindustrial levels, although the base year is sometimes left vague). UNEP (2010b) calculates that to have a reasonable (50-66%) chance of meeting this target, global greenhouse gas emissions would have to return to their 2005 level by 2020, about 45 GtCO2e. Thereafter, they would have to come down by 2.5% a year to fall below 50% of current levels by 2050.

In comparison, the emissions targets pledged under the 2010 Copenhagen Accord could result in global emissions as low as 49 (range: 47–51) GtCO_2e in 2020 if countries implement their conditional pledges with "strict" accounting rules. In the worst case scenario, they could be as high as 53 (range: 52 - 57) GTCO_2e if countries implement unconditional pledges with "lenient" accounting rules (see table 1). Thus under the most ambitious scenario, the pledges could result in 2020 emissions that are 7 GtCO2e less than under business-as-usual, but still leaving a 5GtCO_2e shortfall, which would have to be made up by faster emission cuts after 2020.Importantly, the calculations assume that all pledges would be implemented as planned and without qualification. In the case of the EU this would mean a 30% reduction target for 2020, rather than the current unilateral pledge of 20% (see section 1 for selected Copenhagen pledges), but this is itself dependent upon achieving a legally binding treaty that is satisfactory to the EU.

Table 1. **Expected global emissions in 2020 could be as low as 49 $GTCO_2e$**

Scenario	Expected global emissions in 2020	Emissions gap(central estimate)
No pledges (business as usual)	56 (range:54-60) $GtCO_2e$	12 $GtCO_2e$
Unconditional pledge, lenient rules	53 (range:52-57) $GtCO_2e$	9 $GtCO_2e$
Unconditional pledge, strict rules	52 (range:50-55) $GtCO_2e$	8 $GtCO_2e$
Conditional pledge, lenient rules	51 (range:49-53) $GtCO_2e$	7 $GtCO_2e$
Conditional pledge, strict rules	49 (range:47-51) $GtCO_2e$	5 $GtCO_2e$

Note: Unconditional pledges – lower ambition, conditional pledges – higher ambition;

Lenient rules: cases in which countries maximise the use of surplus emission units and 'lenient LULUCF credits', and thereby weaken mitigation targets. Strict rules refer to cases in which they do not.

Source: UNEP (2010b).

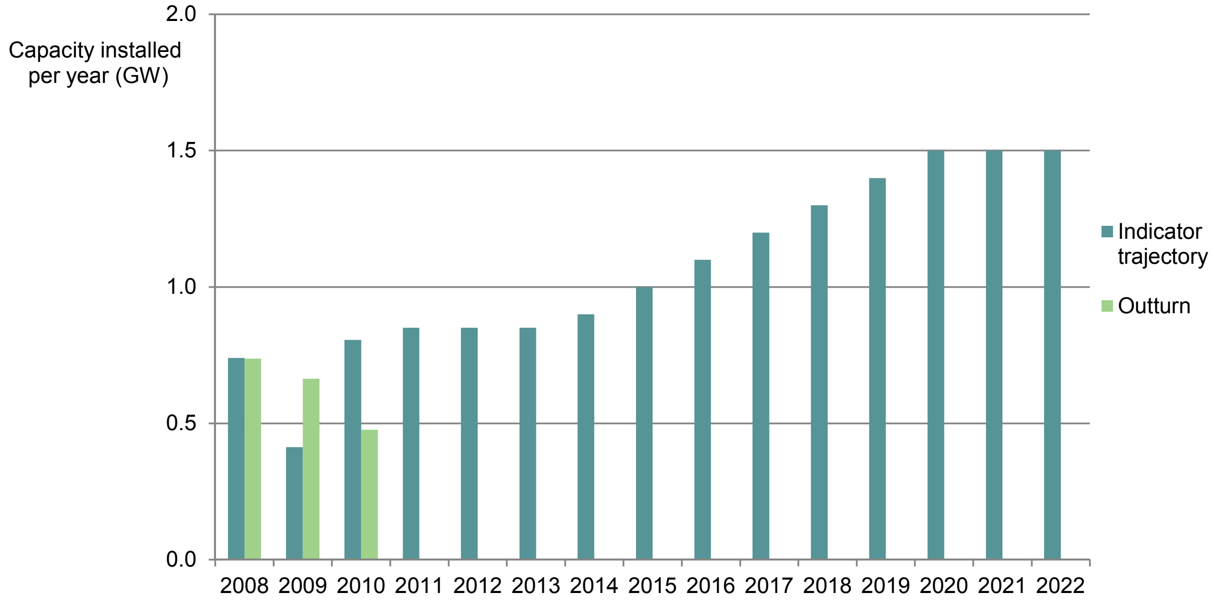
2.2 Electric power generation

The decarbonisation of the electricity sector is the most important and urgent aspect of the UK's green growth agenda. An efficient, expanded and carbon-free power sector is essential to the decarbonisation strategy in other sectors such as transport and heat. Moreover, given the age and replacement profile of existing capacity, the switch to low carbon generation should be completed within the next twenty years when many replacement investments are due. Missing this window would either lock the UK into a high-carbon power generation path or require the premature scrapping of generation assets later on.

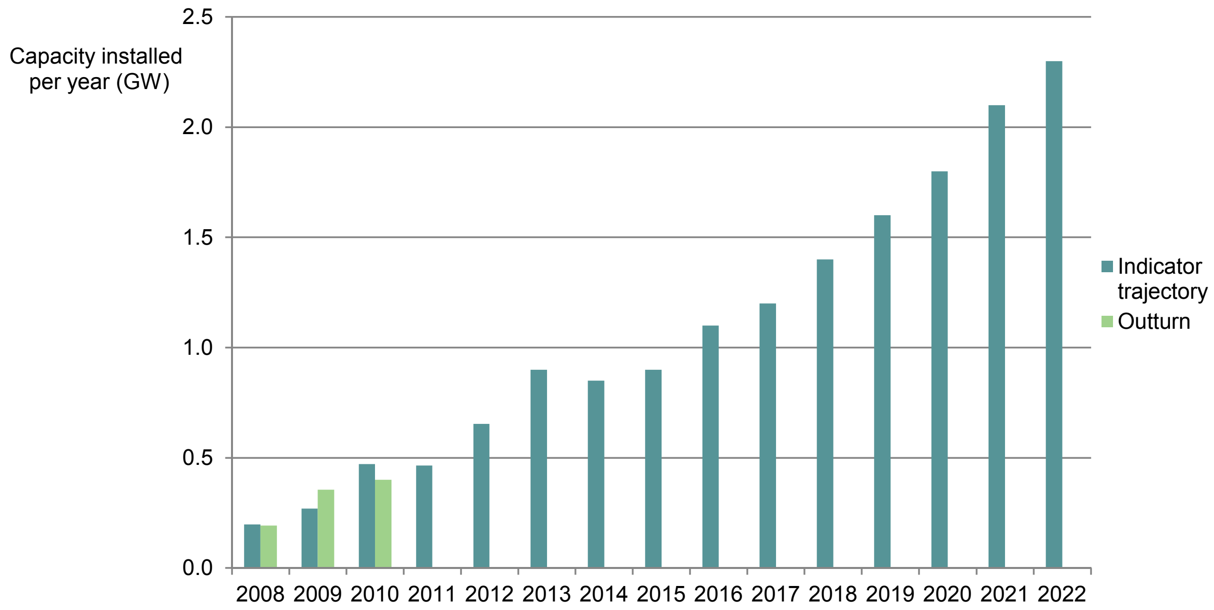
The aim is to reduce the carbon intensity of power generation by 90% within 20 years, from currently about 500 grams of CO_2 per kilowatt-hour (g/kWh) to 50 g/kWh in 2030**.** Decarbonisation of power supply will have to be complemented by demand-side energy efficiency measures, that is, to curtail the growth in electricity consumption. This is covered below.

Figure 4. **A substantial increase is needed in both onshore and offshore wind capacity**

Onshore:



Offshore:



Source: Committee on Climate Change

Achieving this target will require substantial investment in low-carbon generation technology. The indicative roadmap of the Committee on Climate Change (CCC 2010b) envisages the following investments to the early 2020s:

- *Onshore wind:* installed capacity rising from 4GW in 2010 to 18 GW in 2022 (figure 4). This is slightly more optimistic than, but consistent with, DECC's Renewable Energy Roadmap, which suggest the potential for13 (range: 10-19) GW of onshore wind by 2020 (DECC 2011a).
- *Offshore wind*: installed capacity rising from 1.3GW in 2010 to 16.6 GW in 2022 (figure 4). This is in line with DECC (2011a)'s expectation of 18 (10 – 26) GW by 2020.The offshore wind pipeline is currently near 6GW (4GW post-consent and some 2GW in the planning system). Beyond 2020 DECC sees a very high potential for deployment of perhaps over 40 GW by 2030.
- *Nuclear*: While the government remains committed to new nuclear power, events in Japan have led to a review by the Chief Nuclear Inspector and minor delays in the timetable. The interim report of the Weightman Review in May 2011 concluded that '*the direct causes of the nuclear accident in Japan […] are far beyond the most extreme events the UK could expect to experience [...] there is no reason for curtailing the operation of nuclear power plants or other nuclear facilities in the UK*.' Provided any safety concerns are addressed, the CCC (2011a) envisages the first new plant online in 2018, with two further plants added at 18 month intervals. Overall industry plans are for up to 16 GW of new nuclear capacity.
- *Carbon capture and storage*: four demonstration plants starting operations during 2014-16. The CCC also expects the first post-demonstration plant operating by 2022.
- *Grid reinforcement*: new grid capacity to become operational in stages between 2015 and 2018. Grid access arrangements can delay or prevent renewable electricity deployment on and offshore. Currently, 5.5 GW of renewable electricity projects with planning consent do not have an adequate grid connection, according to DECC (2011a).

Other renewable energy sources could contribute to the UK's carbon and renewable energy targets in a smaller way. *Biomass* may play a potential role for co-firing in existing coal-fired plants and in renewable heat, but substantial dedicated new-build is unlikely to occur without CCS. Without CCS, scarce biomass would probably be of more value when used outside the power sector (CCC, 2011b). *Hydro-electricity* may be enhanced through the systematic optimisation of the existing potential, much of it small-scale. *Solar PV* plays a role in small-scale and micro-generation but no large-scale investments are likely. The *Severn Barrage* is economically attractive only at low discount rates and is not currently pursued. With a project lead-time of 13 years it would not be available before the mid-2020s. *Marine technologies* like wave and tidal stream power could play an important role in the future, but may not reach widespread commercial deployment over the next decade.

The Committee on Climate Change's projections for low-carbon electricity generation are similar to those outlined by DECC. The UK Government's National Renewable Energy Action Plan (DECC 2010c) and the more recent Renewable Energy Roadmap (DECC 2011a) both provide indicative roadmaps of how the UK might meet its renewable energy 2020 targets. These foresee a larger role for biomass electricity and renewable heat (air and ground source pumps and biomass) but are otherwise fairly consistent with the CCC view. The Roadmap highlights eight technologies as particularly promising: onshore and offshore wind, marine energy, biomass electricity and heat, ground source and air source heat pumps and renewable transport. As seen above, DECC (2011a) also expects a slightly different mix of off-shore and onshore wind, with more caution about onshore, but a more optimistic stance on offshore.

A range of policies are in place to encourage decarbonisation in the electricity sector. They include:

- the EU Emissions Trading Scheme, currently in its second trading phase;
- a new Carbon Price Floor to support the EU ETS price, announced in 2011;
- a Renewable Energy Obligation (to be replaced by new long-term contracts under the proposed Electricity Market Reform, EMR, pending State Aid approval where required);
- an Emissions Performance Standard (EPS) of 450g CO_2/kWh proposed under the EMR;
- a Feed-In Tariff for small-scale renewable energy generation (up to 5 kW).

2.3 Buildings and industry

The focus in buildings and industry over the next decade is on energy efficiency and renewable heat. By 2022, modelling by the Committee on Climate Change suggests a 23% reduction in non-electric energy use in buildings and industry, and a 13% reduction in electricity use (CCC 2011a; see table 2).From the late 2020s further decarbonisation in the industrial sector will require additional measures such as industrial CCS, process innovation and product substitution.

Table 2. **Indicative buildings and industrial energy efficiency targets (per cent reduction in final energy consumption, 2007 to 2022)**

	Residential	Non-domestic sector		Overall
	Buildings	Buildings	Industry	
Non-electricity	19	13	19	23
Electricity (auto-generation included)	3	1	5	5
Electricity (centrally produced only)	3	1	30	13

Note: Overall target includes the effect of renewable heat, which is not covered in the sectoral targets.

Source: Committee on Climate Change (2011a)

In domestic buildings the Committee on Climate Change calls for a ramp up in energy efficiency. The UK has a relatively old building stock that only slowly turns over. Two thirds of homes that will be in use by 2050 are already built. Consequently, the focus is on refurbishment, although efficiency standards for new homes are also important (HM Government 2010). The Committee on Climate Change uses the following indicators to gauge progress in domestic energy efficiency (CCC 2011a):

- *Insulation*: all lofts and cavity walls insulated by 2015(as of July 2010, 12.3 million of 23.2 million applicable homes had lofts insulated, and 10.3 million out of 18.6 million applicable homes had cavity wall insulation (DECC, 2010)), along with 2 million solid walls by 2020.
- *Boilers*: number of energy-efficient boilers rising from 3 million 2010 to 12.6 million in 2022.
- *Appliances*: share of A+-rated wet appliances rising from 9.5% in 2010 to 58% in 2022; share of A++-rated cold appliances rising from 0.9% in 2010 to 45% in 2022.
- *Zero carbon homes*: all new homes built in England to be carbon-neutral from 2016 and new non domestic buildings from 2019, in accordance with government plans (HM Government 2010).

There appears to be a large untapped potential in non-domestic energy efficiency. A Vivid Economics review of energy efficiency opportunities in the non-domestic sector identified investment opportunities of over £15 billion in the next ten years (Vivid Economics 2011). On the basis of available data, the overwhelming majority of these investments appear cost-effective. A large part of the opportunity is in process efficiency, which tends to be harder to realise as it is industry-specific. However, there are also substantial opportunities in lighting and buildings efficiency.

Across buildings and industry, the share of renewable heat is expected to rise from currently 1% to 5% of heat demand in 2017 and 12% in 2020. According to the Committee on Climate Change 'this would lay the foundations for the deep cuts required in heat emissions in the 2020s' (CCC 2011a).The ramp up is likely to be slow, although support through the new Renewable Heat Incentive may make options like biomass heating, air-source heat pumps and ground-source heat pumps more attractive.

A range of regulatory and price measures are in place to encourage decarbonisation in buildings and industry. They include:

- the EU ETS, which covers carbon-intensive industries like steel, cement, pulp and paper;
- Climate Change Levy (CCL) and Climate Change Agreements, with the CCL applying to all non-domestic consumers and the CCAs applying to energy intensive sectors;
- the CRC Energy Efficiency Scheme which covers large energy users in the service and municipal sectors (e.g. supermarkets, banks, schools, hospitals);
- the Green Deal, scheduled to start in 2012, for energy efficiency in buildings (and which will be subject to a separate State Aid notification);
- supplier obligations that force energy utilities to improve their client's energy efficiency; the current Carbon Emission Reduction Targets (CERT) and the Community Energy Savings Programme (CESP) are to be replaced by new Energy Company Obligations (ECOs) from 2012;
- Compulsory Display Energy Certificates (DECs) and Energy Performance Certificates (EPCs) for public buildings and domestic properties, respectively;
- a Renewable Heat Incentive (RHI) planned for 2012;
- advanced mandatory metering for large energy users;
- the Enhanced Capital Allowance (ECA) scheme providing 100% first-year tax relief on business' capital expenditure on energy-saving equipment.

2.4 Transport

The UK aims to reduce the carbon intensity of new cars from currently around 145 grams per kilometre (g/km) to 95 g/km in 2020. This is in line with EU's *Passenger Car Regulation*[11] and would translate into an average carbon intensity for the entire fleet (new cars and old) of 102 g/km in 2020, compared to around 164 g/km now (CCC 2011a). The target would primarily be reached through efficiency gains in traditional vehicle technology but also through a down shift from larger to smaller cars. Similar EU targets for vans were agreed in 2011 in the EU's *Van Regulation*[12]. They require carbon efficiency levels in new vans of 175 g/km by 2017, with the share of vans meeting this targets gradually increasing over time. By 2020 new vans should not emit more than 147 g/km[13].

In the medium term further efficiency improvements will have to come from new technologies, such as battery electric vehicles, plug in electric vehicles and perhaps fuel-cell-based vehicles. The Committee on Climate Change expects that 600,000 electric cars will be registered annually by 2020 (CCC 2010a), with a sharp increase in uptake in the early 2020s. By 2030 60% of new cars and vans could be electric (CCC 2010a), compared with just 167 electric cars registered in 2010.

The uptake of electric vehicles will have repercussions on electricity demand and require a recharging infrastructure. The exact extent of these demands is still a matter of debate. More needs to be learned, for example, about people's recharging preferences and the demand for recharging points in areas other than work places and homes. The Government's Plugged-in Places (PiP) programme has made £30m available to match-fund eight pilot projects installing and trialling recharging infrastructure across the UK with up to 8,500 charge points.

The Renewable Transport Fuel Obligation requires the share of biofuels in road vehicle fuels to increase to 5% by 2013/14. This compares to 3.5% in 2010/11.The target is consistent with the findings of the Gallagher Review (Renewable Fuel Agency 2008), but lower than the EU's 10% target. In its renewable energy review (CCC 2011b) the Committee on Climate Change recommends a liquid biofuel target of 8% by 2020. Given concerns about the sustainable sourcing, the role of biofuels in surface transport is likely to remain limited to niche markets like buses, taxis and HGVs. Scarce biofuels may be better used in air transport where there are fewer low-carbon alternatives. However, successful research into second generation biofuels (biofuel produced from any plant material without conflict between food, energy and environmental needs) over the coming decade may allow biofuels to play a larger role in long-term decarbonisation.

[11] REGULATION (EC) No 443/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO2 emissions from light-dduty vehicles

[12] REGULATION (EU) No 510/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 May 2011 setting emission performance standards for new light commercial vehicles as part of the Union's integrated approach to reduce CO2 emissions from light-duty vehicles

[13] These targets are legally binding on the manufacturers rather than the UK. However, the UK is obliged to monitor progress and to report to the EU on its manufacturers' progress.

Car efficiency measures have to be complemented by behaviour change, such as eco-driving, adherence to speed limits and 'smarter choices'. The 'smarter choices' pilot of techniques to influence travel behaviour (e.g. through car sharing, working from home, travel planning etc.) has been relatively successful and could be rolled out more broadly. The Committee on Climate Change also envisages that 4.5 million drivers would have had eco-driving training by 2022.

In public transport, the focus is on upgrading the railways infrastructure and on providing low-carbon buses. The government promises '*a new wave of low-carbon public transport*', encouraged by incentives for bus operators and local authorities to buy new hybrid and electric vehicles. Around 170 new vehicles could be purchased by March 2012 (HM Government 2010). In railways, network operator Network Rail plans to electrify, by 2016, the Great Western Main line from London to Didcot, Oxford and Newbury and the lines between Liverpool, Manchester, Preston and Blackpool. Rolling stock companies are expected to invest in more than 2,100 new carriages including rolling stock for the Thameslink and Crossrail projects[14]. However, railways investment is dominated by plans for new track infrastructure, including a new high-speed rail link (the HS-2 project), which could commence in 2017, and on-going projects like Crossrail and the upgrade of the London underground network.

A range of regulatory and price measures are in place to encourage lower surface transport emissions and modal shift from road to more sustainable forms of transport. They include:

- a fuel duty: although primarily a revenue-raising tax, it has considerable impact on driving and car purchase decisions;
- differentiation in vehicle excise duty (road tax) in favour of more fuel-efficient cars;
- differentiation in company car taxes in favour of more fuel-efficient cars;
- behavioural programmes like smarter choices (where there is a potential to extend the pilot scheme) and eco-driving courses;
- a government subsidy on electric cars of up to £5000;
- renewable Transport Fuel Obligation about the use of biofuels;
- a Freight Facilities Grant to help offset the capital cost of providing rail and the Mode Shift Revenue Support to cover the additional operating costs of transporting goods by rail.

2.5 Waste

The UK strategy on waste management dates from 2007. The strategy has five objectives, summarised below (see also table 3):

- decouple waste growth (in all sectors) from economic growth and put more emphasis on waste *prevention and re-use;*
- meet and exceed the *Landfill Directive diversion targets* for biodegradable municipal waste in 2010,

[14] www.dft.gov.uk/news/press-releases/dft-press-20101125.

2013 and 2020 (see table 3);

- increase diversion from landfill of *non-municipal waste* and secure better integration of treatment for municipal and non-municipal waste;
- secure the *investment in infrastructure* needed to divert waste from landfill and for the management of hazardous waste;
- derive the most environmental benefit from that investment, through increased *recycling of resources and recovery of energy* from residual waste using a mix of technologies.

DEFRA's Government Waste Policy Review (2011) reiterates the objectives set out in the Waste Strategy for England 2007. The government relies heavily on a landfill tax to divert waste from landfill. The standard tax rate is currently set at £56 per tonne in 2011/12 and will rise by £8 per annum, to £80 by 2014/15, with a minimum floor under that level of tax until at least 2020. The landfill tax has rendered the Landfill Allowance Trading Scheme superfluous, and as such the latter will be brought to an end in England after the completion of the 2012/13 scheme year. In addition seven waste infrastructure products were deemed no longer eligible for the PFI credits which had provisionally been allocated to them, as they are no longer needed to meet the 2020 landfill diversion targets set by the European Union.

New measures are likely to be implemented in the future. In 2012 DEFRA will start a consultation on introducing a restriction on the land-filling of wood waste. Following on from that, further restrictions (on textiles and biodegradable wastes especially) will be taken into consideration. Furthermore, a new Packaging Directive is expected from 2014. There is a clear need for alternatives to landfill. Around 300 of the UK's largest landfill sites may have to close as a result of UK and EU waste management targets and be replaced by modern waste management facilities (CBI, 2011).

The level of additional, modern waste management capacity needed by 2020 ranges from about 700 ktpa to 2,900 ktpa (although in some scenarios no further capacity is required). This is for both energy-from-waste (EFW) and material recovery facility (MRF) sites. According to Vivid Economics calculations, a medium range estimate for EFW would be 630ktpa, which at an average facility capacity of 200 ktpa would imply the need for an extra 3 EFW sites to be built by 2020 (estimates range from 0 to 4). For MRF, the medium value is 1,235 ktpa, and the average facility capacity is 30 ktpa, which translates into a need of c. 40 MRF plants to be built by 2020 (estimates range from 0 to 74). The London Waste and Recycling Board (LWARB) intends to create a revolving fund to reduce London's projected waste management capacity gap from 8.5 million tonnes to around 4 million tonnes by investing in low carbon waste infrastructure.

Table 3. **The UK has increasingly strict waste management targets**

Type of Waste	Biodegradable Municipal Waste	Municipal Solid Waste	Household waste	Household waste
Target	Amount sent to landfill as percentage of amount in 1995	Proportion of waste stream from which value is recovered	Proportion of waste stream recycled or composted	Amount not re-used, recycled or composted as percentage of amount in 2000
Legally binding?	Yes	No	No	No
2010	75%	53%	40%	71%
2013	50%			
2015		67%	45%	
2020	35%	75%	50%	55%

Source: Norlands Report, Defra

2.6 Water

The UK water sector faces new challenges that will require additional investment as well as sound policies. The Government and the water regulator for England and Wales, Ofwat[15], both recognise that the *'sector faces a number of new challenges that could have big effects'* and that *'the solutions of the past will not be enough to continue to deliver the services of the future* (Ofwat, 2010a)**.** The challenges that the sector recognises it will have to face include:

- *Compliance with environmental standards*: Water abstraction from 11% of rivers and 35% of groundwater is potentially environmentally damaging according to Environment Agency statistics (as quoted in ASC 2011);
- *Rising demand*: Without efficiency measures water demand is increasing steadily as incomes rise and the population grows;
- *Adapting to climate change*: While only 8% of water resource zones in England are currently not ready for a severe drought, this is projected to increase 45% by 2035 without corrective action (ASC 2011);
- *Mitigating the effects of climate change*: hot water for personal use, cooking, cleaning and washing accounts for 26% of domestic energy use (Ofwat 2010b);
- *Affordability*: Meeting these challenges while protecting consumer interests is at the core of Ofwat's mandate.

Between 2010 and 2015 more than 50% of investment by water companies in England and Wales will be focussed on maintaining and replacing assets. These targets were set in the latest price round that determines investment by water companies on a five year cycle. The 2010-15 price round further allocates 21% of investments to improvement in drinking water and better environmental outcomes. Further amounts

[15] In Scotland the water industry is regulated by the Water Industry Commission for Scotland (WICS).

will be spent on expanding water resources and sewage capacity (12%), improving service levels to consumers (especially reduced sewer flooding) (5%) and delivering bespoke big projects (4%).

There are also plans to reduce the number of properties in the highest sewer flood risk category by 1,368 homes. This is a 27% reduction in the high risk register from the forecast position of about5,000 properties (as at March 2010).In cases, where permanent solutions for sewer flooding are not cost-effective, significant mitigation measures have been undertaken, such as installing ‘flap valves’.

Water utilities are contemplating a number of large projects, both under the current price round and beyond. By 2022, there are expected to be 5 new reservoirs and 3 reservoir extensions in the UK, including Thames Water’s ambitious £1 billion reservoir in Abingdon. This would be the largest of its kind in the UK and contain 150 million cubic metres of water. Investment plans also include structures to improve the water quality in the river Thames including the construction of the Lee Tunnel (scheduled for completion in 2014) and Thames Tunnel (scheduled for completion in 2020) that would avoid large volumes of waste discharge into the Thames.

The investment plans of water companies beyond 2015 have not yet been subject to detailed regulatory scrutiny. However, the Strategic Direction Statements of water companies suggest that issues to be addressed will include major water resource transfers and new reservoirs, the need to develop drainage systems that can cope with more intense storms expected from climate change, coastal flooding, reducing leakage, and increasing meter penetration

In addition to the regulatory process which ensures that companies can finance agreed efficient levels of capital investment, there are a number of policies to promote sustainable development in the water sector. These include:

- minimum water efficiency standards for all new homes of 125 litres per person per day;
- minimum standards for the use of water in certain fittings and appliances e.g. toilets, washing machines and dishwashers;
- extended powers for water companies to increase compulsory metering in areas that are seriously water stressed.

3 The funding needs of the green economy

This section analyses what the UK's transition to a green economy might cost in terms of additional green investment. It demonstrates that the additional capital needs in the green economy are substantially higher than past investment levels. The additional capital required goes beyond what companies in these sectors have been able (or willing) to raise in the past. Green capital needs are small relative to the overall level of investment in the UK, although by 2020 they could account for a substantial fraction of gross fixed capital formation. The challenge is to redirect enough of the existing investment flows into a green direction.

The section translates the roadmap introduced in the previous section into an indicative investment plan and compares it with current investment. The comparison is made at three levels:

- *Future vs. past investment in the green economy:* This shows to what extent investment into the green economy has to be ramped up.
- *Future green investment vs past fundraising*: This illustrates the ability of firms in the green economy to raise additional capital, although that capital may not have been allocated to green purposes in the past.
- *Future green investment vs overall gross fixed capital formation:* This puts investment in the green economy into perspective by showing total investment activity in the UK.

The section concludes with a synopsis of the international situation.

3.1 Green investment needs in the next decade

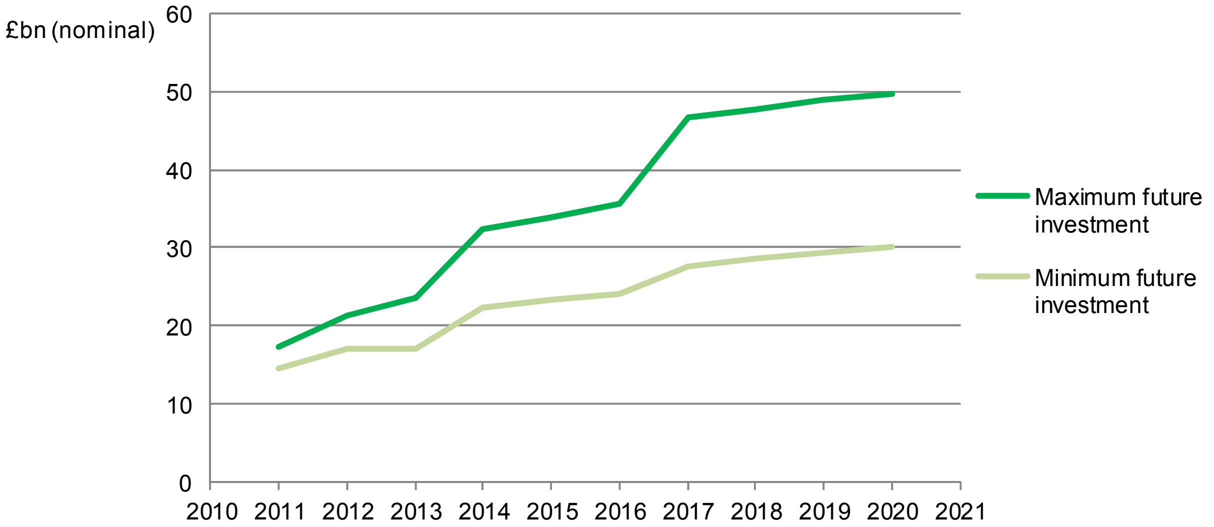
The indicative roadmaps outlined in section 2 could imply cumulative investment needs in excess of £330 billion over the period 2011 – 2020 in the UK. Investment needs increase steadily over the period with the annual investment requirement in 2020 close to£50 billion (see figure 5)[16]. Although not shown in the figure, the green investment needs are likely to be sustained, or even increase, beyond 2020.The estimate is broadly supported by other studies. According to DECC, up to £110 billion may be required for electricity generation and transmission investments alone in the UK (DECC 2011b). This is a fairly representative industry number, although Ofgem's Project Discovery (2009) suggests £200 billion for a broader set of energy investments (including for example new LNG terminals and renewable heat). Ernst &Young (2010) envisage capital requirements in the UK of up to £450 billion (including energy efficiency) until 2025.

There is considerable uncertainty over the precise investment profile. A number of factors, over and above those related to the GIB, will determine the precise scale and pace of the future investment requirement including the cost reductions achieved by technologies, and the efficacy of complementary policies and the planning regime. However, even in a minimum scenario, cumulative green investment might

[16] This excludes investment in railway infrastructure like HS-2.

exceed £220 billion, with an annual investment need of £30 billion per annum by 2020 (figure 5). The two scenarios are described further in the annex.

Figure 5. **Green economy sectors may require £30-50 billion p.a. by 2020**



Source *Vivid Economics based on various sources (see Annex for details)*

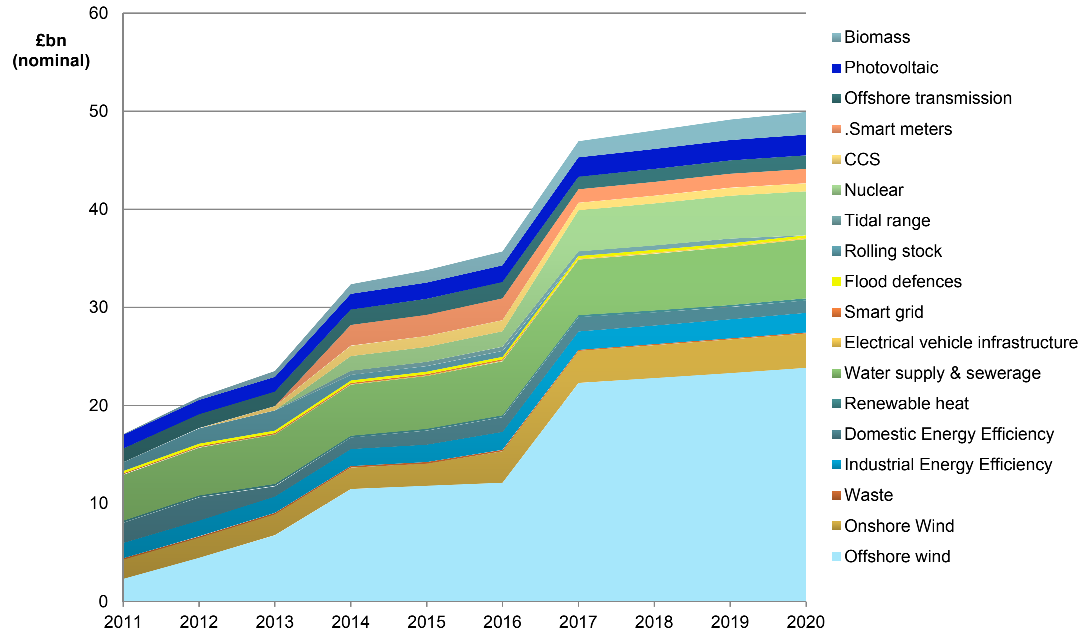
The bulk of the future investment is expected to be for offshore wind (see figure 6). Other sectors which account for a material proportion of the total investment needs are water and sewerage (although most of the spend in water might be for traditional as opposed to green projects), nuclear – reflecting a need to replace all but one of the UK's nuclear plants within the next two decades (subject to the findings of the Weightman Review later this year, see section 2.2) – and onshore wind.

Many sectors will require year-on-year increases in investment. It is expected that the onshore and offshore wind sectors will see an immediate step-up in investment from the beginning of the decade, followed by sustained year-on-year increase in investment at least up to 2020 and probably beyond. Broadly similar patterns are expected in industrial energy efficiency, offshore transmission and renewable heat. In the case of nuclear and CCS there will be a few years before the investment requirement becomes substantial (2017 for nuclear and 2022 for CCS).

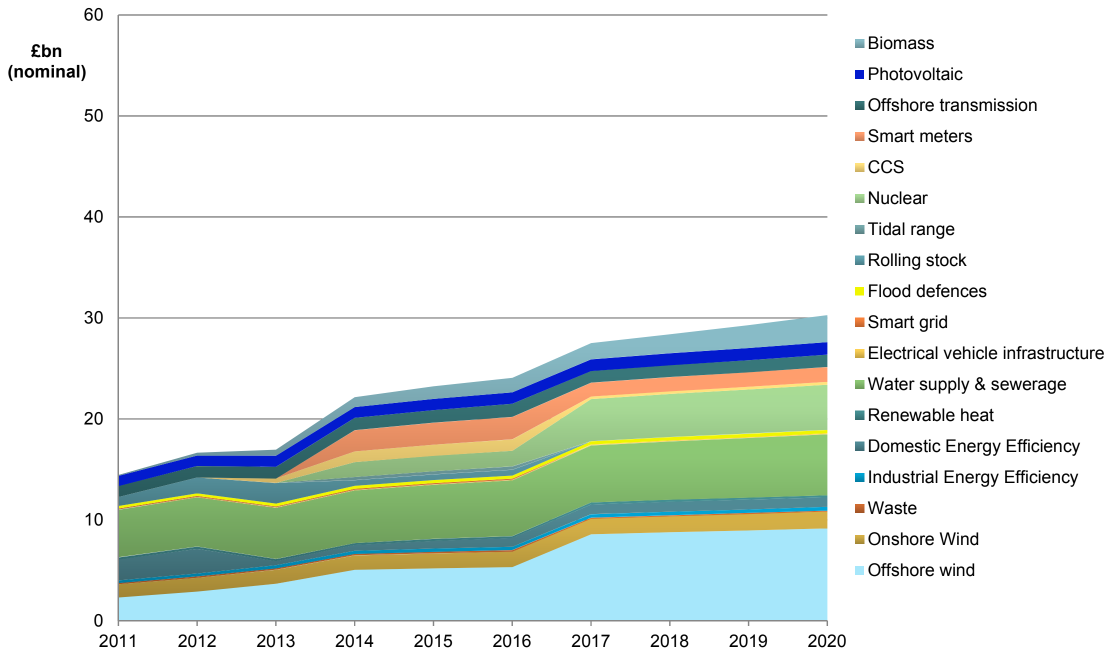
Some sectors (rolling stock, tidal range and smart meters) experience a temporary demand spike in the middle of the decade. In the case of rolling stock, investment demand peaks in 2013 at around £2 billion (nominal prices), and tapers off before the end of the decade. This is due to the mid-decade deadlines for the delivery of rolling stock for the Thameslink, Crossrail, and Intercity Express programmes. There could be more rolling stock demand in the latter half of the decade, but there are no projections at this point.

Figure 6. **Medium-term green investment needs are dominated by the offshore wind sector**

Maximum investment needs per annum, medium-term (all sectors)



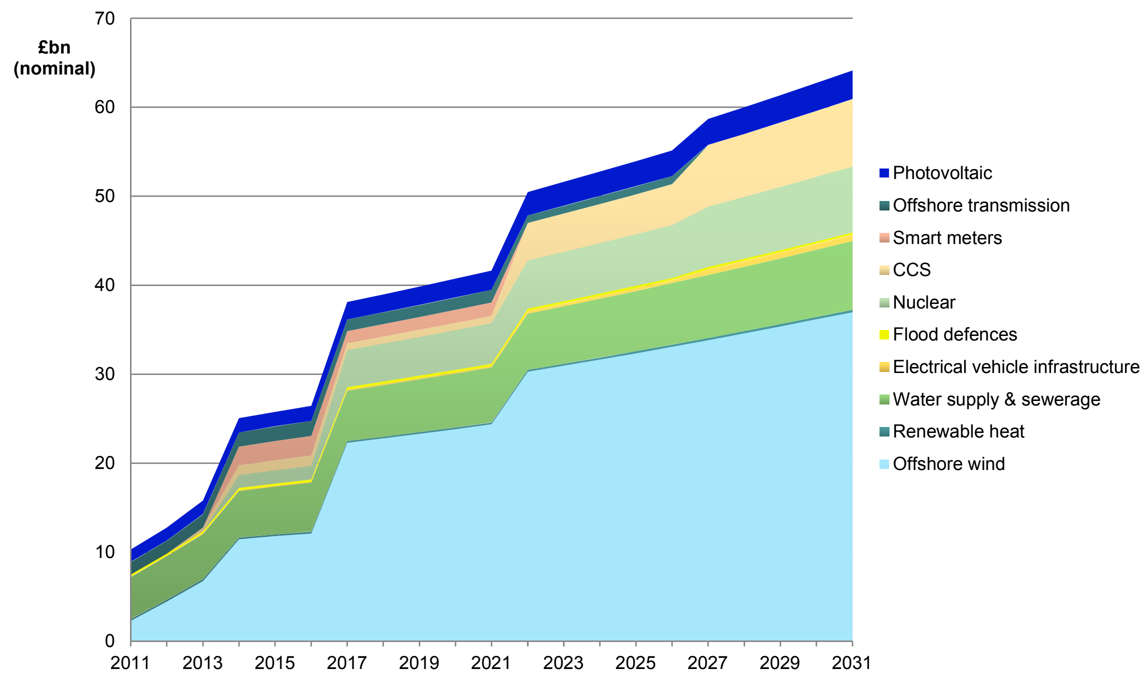
Minimum investment needs per annum, medium term (all sectors)



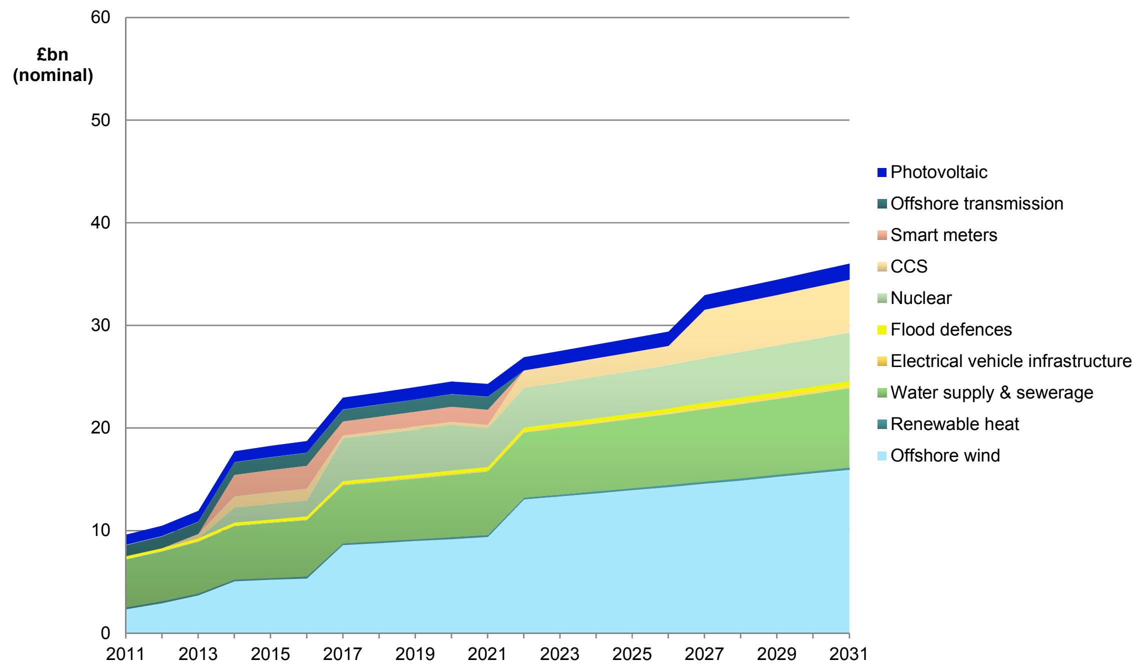
Source *Vivid Economics calculations. See Annex for more data sources and assumptions, and drivers of difference between the two scenarios*

Figure 7. **For many green sectors investment needs will continue to grow through the 2020s.**

Maximum investment needs per annum, long term (selected sectors)



Minimum investment needs per annum, long term (selected sectors)



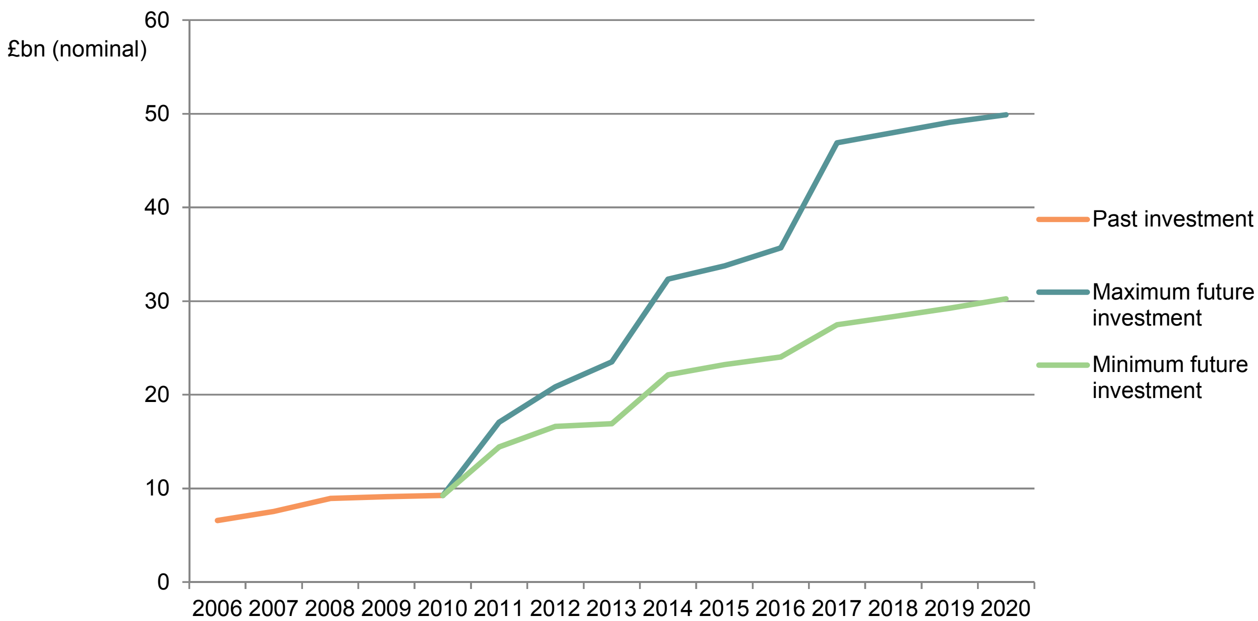
Source *Vivid Economics calculations. See Annex for more data sources and assumptions, and drivers of difference between the two scenarios*

Demand for investment will continue to grow beyond 2020. Data beyond 2020 are patchier and investment needs less certain. However, for the sectors where credible long-term forecasts are available the upward trend continues. Figure 7 shows this for a subset of 10 sectors: offshore wind, renewable heat, water supply and sewerage, electrical vehicle infrastructure, flood defences, nuclear, CCS, smart meters, offshore transmission and photovoltaics.

3.2 Future green investment and past green investment

Past investment in the green economy has been much lower than required in the future. Figure 8 shows the same future investment profile as shown in figure 5, but also includes the historic perspective of the period 2005-2011. It shows a clear kink in the level of green investment required in the UK, and a steep rate of increase. Whereas historic green investment has been in the region of £6 billion to £8 billon per annum, even in the near future (2011-2013) green investment is expected to be at least twice this amount, while by 2020 it is expected to be between four times and six times higher than historic.

Figure 8. **There is a discontinuity, a 'kink', between past and future green investment rates**



Source *Vivid Economics calculations. See Annex for more details*

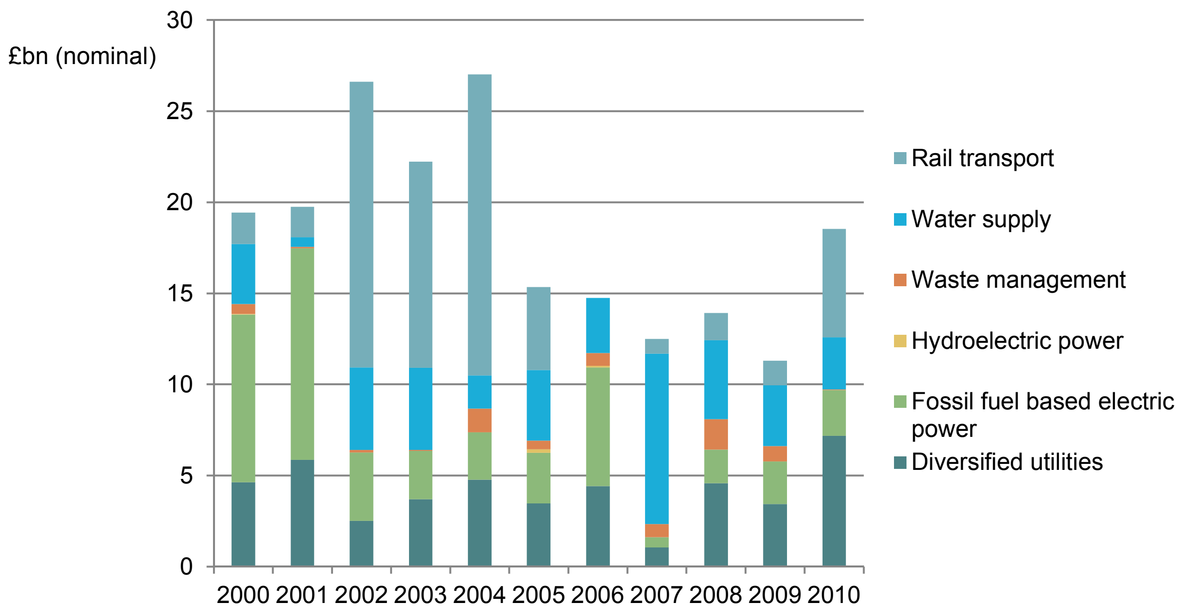
In particular sectors, the acceleration in investment is even more dramatic. Investment in the offshore wind sector in 2020 is expected to be between seven and twenty times higher than its 2010 estimated amount. Ernst & Young (2010) report annual average investment needs of £15billion for low-carbon energy supply out to 2025 (plus the same amount again for energy efficiency). According to their estimate this is three to four times what traditional sources of capital typically provide.

3.3 Future green investment and the ability to raise capital

In the last decade UK companies active in green sectors have raised around £15 billion a year on average. Fundraising efforts were highest in 2002-2004, when they exceeded £20 billion a year. They fell by almost half between 2005 and 2009, but recovered to £18 billion in 2010 (see figure 9). These numbers include bond issues, syndicated loans and rights issues by power generation companies, waste management companies, water utilities, railways operators and diversified utilities. The figure excludes the gas sector, which has raised over £7 billion a year since 2008.Water companies and diversified utilities dominate the picture, followed by power producers.

Not all fundraising is for investment and not all investment is "green". Firms also raise money for acquisitions, working capital, buy-outs or to restructure the balance sheet. For example, the spike in 2007 for water was for refinancing rather than new assets.

Figure 9. **Green infrastructure companies raise between £11 billion and £27 billion a year**

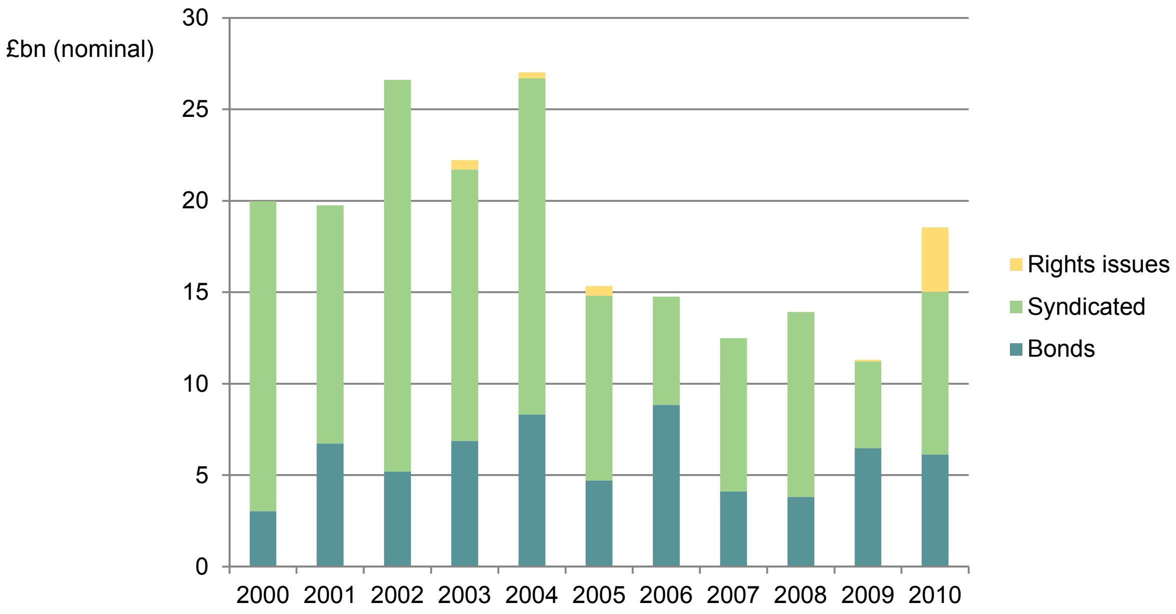


Source: McKinsey based on Dealogic

Fundraising is dominated by syndicated loans and to a lesser extent by corporate bonds. Syndicated lending accounts for about two thirds of funds raised over the last five years (see figure 10 below). Bonds account for most of the rest. However, bond transactions are more frequent. In 2009/10, there were 72 bond transactions raising an average of £330million each. The 30 syndicated loans over the same period raised an average of £460 million each.

Rights issues are rare, but there is a vibrant M&A sector. Firms in the green economy rarely issue new shares to raise additional capital (see figure 10). However, mergers and acquisitions (M&A) is an active field. A recent survey on M&A in the renewables sector – covering mergers, acquisitions, minority investments and private equity transactions (including buyouts, public-to-private deals and secondary buyouts) – reports a 70% increase between 2009 and 2010 in the *number* of renewables M&A transactions worldwide, from 260 to 446 deals. In Europe much of this was driven by government incentives. Among UK investors 38% are driven by government incentives, more than any other factor. The effect of policy can be both positive and negative. Adjustments in feed-in tariffs in Spain, for example, have triggered a wave of disposals as asset owners adjusted their portfolios. As a result the *value* of transactions decreased from US$ 44 billion in 2009 to US$ 26 billion in 2010. However, a full two thirds of survey respondents expect valuations to recover over the next 18 months (KPMG 2011).

Figure 10. **Syndicated loans are the main funding source, followed by bonds**



Source McKinsey based on Dealogic.

Data on margins is limited but suggests firms in the green economy sectors often pay a premium for debt. In part this is because of the long tenor of funds, but it also reflects the risk profile of these companies, which are seen as less secure than average. In 2009, 10 firms in the green sectors were offered an average margin of 333 basis points on syndicated debt, compared with an overall average of 221 basis points. However, there was no significant difference in the pricing of bonds, and pricing patterns before the recession were uneven That being said, the data is patchy, thus this figures need to be treated with caution.

3.4 Future green investment and total capital formation

Future green investment needs are a small but rapidly growing fraction of overall gross fixed capital formation (GFCF). In 2010 GFCF in the UK was around £200 billion, according to ONS data – below the pre-crisis maximum of £245 billion in 2007. Of this, about £120 billion, or 60%, was business investment, with general government investment and construction accounting for the rest. Green investment over the next few years will be a relatively small fraction of this overall capital accumulation, worth less than 10% of the total, but nearly twice as large a fraction of business investment (see section 3.1).

However, green investment needs are large relative to total investment in electricity, gas and water. In 2010, ONS data shows capital expenditures in electricity, gas and water were under £9 billion[17]. This is less than the green investment required over the next few years, even if non-utility demands (e.g. for energy efficiency) are stripped out. This underscores the fact that the transition to a green economy will require an increase not just in green capital accumulation, but overall energy, gas and water investment.

Green investment demand is rising much faster than the likely growth in GFCF. If up to £50 billion a year is to be invested in the green economy in 2020, as figure 5 implies, green capital accumulation would by that time become a key investment destination. This is true even if we account for the likely growth in GFCF over the next 10 years. In the pre-recessionary period between 2001 and 2007, ONS data reveals that the average annual growth in GFCF was just over 4%.This compares to an annual growth in green investment of maybe 12 - 19% over the next decade (according to figure 8). Extrapolating past GFCG growth rates (from ONS data) implies that by 2020, green investment might account for perhaps 10 – 17 % of UK gross fixed capital formation[18].

3.5 The international situation

It is worth comparing UK financing patterns and funding needs with the European and global situation. This is relevant for two reasons. First, many utilities active in the UK are foreign-owned (usually European) and may thus be able to raise money at parent level on the international market. Second, UK companies may compete with European and global firms for capital. Similarly, UK subsidiaries of international companies will compete with the local branches in other countries.

European investment in the green economy has to double and eventually rise by a factor of eight. The European Commission (2011b, c) expects that meeting the targets in the EU renewable energy roadmap will require an increase in public and private investment of €270 billion a year on average until 2050. This would represent an additional investment of around 1.5 per cent of EU GDP per annum on top of the overall current investment representing 19 per cent of EU GDP in 2009[19]. Over the next decade renewable energy investment has to double from currently €35 billion a year to €70 billion.

European firms in the green economy have typically raised around €110 billion a year (£94 billion at current exchange rates) since 2005. Conventional power generators and diversified utilities dominate,

[17] The fact that green investment was around £8 billion in 2010 (see figure 7) suggests that gas and conventional energy investment (included in the ONS figure, but not the green investment estimate) was similar in size to investments in waste, rolling stock and energy efficiency (included in the green investment estimate, but not the ONS figure). The difference with the fund raising estimates of section 3.3 is explained by the need to raise funds for purposes other than investment (e.g. working capital, acquisitions, leveraged-buyouts etc.).

[18] Extrapolating GCFC to 2020 using the historic growth rate of 4% gives an estimated figure for GCFC in 2020 of about £300 billion. Comparing that to estimates of green investment of £30-50 billion results in a range of 10-17% for the percentage of green investment in GCFC.

[19] European Commission (2011b, c).

raising over 80% of funds. Unlike in the UK, water utilities have raised very little, around 5% of the total. As in the UK syndicated lending accounts for around two thirds of EU funds raised, and bonds for much of the rest. Rights issues are rare.

Total gross fixed capital formation in the EU is around €2.2 – 2.6 trillion, according to Eurostat. About 60% of this is business investment. As in the UK, around 10% of total EU investment will therefore have to be devoted to the green economy over the coming decades.

Global investment needs are even higher. According to the International Energy Agency (2010) low-carbon energy investment is currently about US$ 165 billion a year. To implement the IEA's low-carbon (BLUE Map) scenario, this will have to rise to US$ 750 billion per year by2030 and to over US$ 1.6 trillion a year from 2030 to 2050 (IEA 2010)[20]. Vivid Economics analysis based on this roadmap suggests that to meet these goals, annual investment in key low-carbon electricity generation technologies will, even for the relatively mature technologies such as wind and hydro, need to increase by about 50%. The same analysis also shows that annual investment in electric and plug-in hybrid vehicles will need to grow from practically zero to an annual average of USD 1,400 billion per annum (although most of this will replace conventional car sales).

[20] Much of this investment is on the demand side (e.g. for cars and consumer products). That is, the IEA's investment scope is broader than that in this report.

4 Potential sources of new finance

This section contrasts the demand for fresh capital, outlined in section 3, with potential sources of finance. It suggests that, while international and domestic capital flows are ample, there are barriers, e.g. related to risk appetite and the risk profile of green investment that may constrain the flow of additional capital into the green economy in the short term. The section starts with a review of generic barriers to finance and then reviews the principal sources of additional finance: increased equity (through retained earnings or the issuance of new shares), debt finance (either on- or off-balance sheet) and bonds.

4.1 Barriers to finance

There are a number of market failures which are affecting the financing of green projects. Vivid Economics (2011) and BIS (2011) highlight the following as the most important:

- *Risk aversion* resulting from a lack of information, the absence of a track record and the incapability of evaluating projects fully;
- *High (perceived or real) transaction costs:* while transaction and learning are real costs, they may be exaggerated for novel technologies without a track record;
- *Imperfect or incomplete information:* energy efficiency opportunities are one example, whereby energy users do not realise the potential savings they could make and invest less as a result;
- *Principal-agent problems*: the information asymmetry between landlords and tenants may prevent the former from recouping efficiency investments through higher rents; information asymmetries between managers and shareholders may restrict the freedom of the latter to expand capital investment much ahead of profits (Stiglitz et al 1993);
- *First mover disadvantage*: novel technologies (e.g. deep water wind projects) entail learning costs borne by the first mover but shared, as a positive externality, with followers;
- *Public goods in infrastructure*: investments like flood defences provide a public benefit, but do not translate easily into a profitable investment, thus resulting in under-provision;
- *Policy uncertainty:* green investments rely on government policies, which must be in place long-term; the lack of track record in long-term green policies is a risk to investors (but internal to policy makers). For example, investor uncertainty ahead of new policy announcements by a new government may have contributed to the UK's low investment in green projects in 2010 (Pew, 2011).

The magnitude of low-carbon investment might also be too big for the financial sector to get involved at scale. Excluding post-war reconstruction, the scale of the investment needed is unprecedented. Only £11bn was invested in Britain's 'dash for gas' in the 1990s, which was considered transformational at the time (GIB Commission, 2010). When financial needs of unprecedented magnitude arose in the past, the response has often been the creation of a public bank, as we will see in section 6 (e.g. IBRD, EBRD).

4.2 New equity investment

There are natural limits to the pace at which fresh equity can be raised by existing firms. Companies typically try to maintain stable net earnings and dividends over long periods of time. However, this is not possible when companies move from periods of low investments into periods of high investment. Additional equity capital is generated mostly through retained earnings rather than equity issuance (Auerbach and Hassett, 2003; Myers, 1984). This is in part because firms that are forced to seek external capital from markets may see their cost of capital increase (Vivid Economics 2011). However, it is not easy for firms to increase the proportion of earnings which they retain. Listed firms seek to maintain steady dividends, because stock market valuations may respond to unanticipated dividend changes (Miller and Modigliani, 1961). Many investors, such as pension funds, need to maintain income to match their outgoing obligations (Brealey and Myers, 1996; Gordon 1959). These constraints may slow down the speed of expansion below what government targets require, even if they were not exacerbated by principal-agent problems, which constrain the ability of managers to expand capital investment ahead of profits (Vlieghe 2010; Stiglitz et al 1993).

Current economic conditions are likely to limit the quantity of equity that is available in the short, medium and long term. They may particularly affect the number of investors willing to make investments which they view as exotic, such as offshore wind**.** In some sectors, firms' profits have been cut both by a reduction in quantity demanded and by an associated fall in margins as capacity has moved into over-supply. This reduces access to capital (Gertler, 1988). With lower profits, there are fewer internal resources for investment. It is also because, as market volatility has increased (Bank of England, 2010), investment has been discouraged (Dixit and Pindyck, 1994). This is likely to hit exotic sectors harder than most: the Bank of England reports on market sentiment that *'increases in the required compensation for uncertainty around future dividends [is] linked to the general retrenchment from risky assets'* (Bank of England, 2010). Against a background of increased risk, capital availability has declined, particularly in sectors where the policy environment is perceived to be inconsistent (see section 4.1).

The challenges in raising new equity are demonstrated by historic experience. As seen in section 3, firms in the green economy have been reluctant to increase their capital base through rights issues in the past. The GIB can add equity capital and may also act as a catalyst, generating additional or accelerated investment if it can overcome some of the market failures relating to information and public goods at the same time. However, there is much merger and acquisition activity to consolidate or dispose of renewable energy assets or change the ownership of companies. This market was worth US$ 26 billion globally in 2010 (KPMG 2011).

The UK's attractiveness for renewable investors is held back by inconsistent regulation. The USA, China and India were the most favoured investment destinations among renewable energy investors in a 2011 survey (KPMG2011). The UK was mentioned favourably by a third of respondents, with half of the European respondents contemplating UK transactions over the next 18 months. Only Germany scored higher in Europe. However, a full 75% of respondents had committed less capital to the UK in the past than they would have done with clearer and more consistent regulation

Capital injections by institutional investors are likely to remain rare. There was much excitement when two Danish pension funds took a US$ 1.1 billion (50%) stake in Denmark's largest off-shore wind farm.

However, this remains the exception and the institutional investors were isolated from most risks. According to KPMG (2011),

> "*Institutional investors are not ready yet [to invest in the green economy]. The general consensus is that if you get two years into commercial operations then getting involved in refinancing won't be an issue. The problem is getting through construction and the first couple of years.*"

According to KPMG (2011) only 20% of industry experts expect pension funds to play an active role in renewable energy over the next 18 months. For these risk-averse institutions to invest large amounts of capital in green sectors, innovative financing solutions to hedge against the numerous project development and supply chain risks will be needed. As institutional investors are sceptical about investing in the construction phase of a green project, the GIB could step in and share those risks. Utilities, and to a lesser extent specialised infrastructure funds and independent power producers, are expected to dominate the mergers and acquisitions market.

4.3 Bank debt

Banks can provide additional debt capital, either through traditional corporate lending or through project finance vehicles. Supplier finance (early payment by a bank or a factoring company to a supplier, based on invoices qualified by the buyer) is particularly used in the manufacturing sector, but is less common in the green economy. Figure 10 shows that syndicated lending (bank debt) has been an important source of capital for companies involved in the green economy, accounting for around two thirds of total capital raised in these sectors. This may either take the form of standard corporate lending by banks to companies or project finance – debt provided off-balance sheet to 'special purpose vehicles' (SPVs), legally separated from the remaining activities of the project's sponsors with debt repayment (intended to be) determined solely by the performance of the SPV.

The broader macroeconomic environment is placing constraints on the amount of debt that banks can provide. Following the financial crisis, and in light of the on-going sovereign debt problems in some European countries, banks have been repairing their balance sheets by restricting lending. This is partly in response to specific policy requirements. For instance, Basel III will require banks to increase their core tier-one capital (includes common shares and disclosed reserves) from 2% to 4.5% by 2015 and carry a further 'counter-cyclical' capital conservation buffer of 2.5% by 2019. This will bring the total tier-one capital to 7%. Any bank that fails to meet the new requirements is expected to be banned from paying dividends to shareholders until it has improved its balance sheet. UK regulators are expected to require more than the Basel III minimum (Miles, Yang and Marcheggiano, 2011). McKinsey analysis (2010) suggests that, absent any mitigating actions, European banks may face a Tier 1 capital shortfall of around €1.1 trillion, a short-term liquidity shortfall of €1.3 trillion and a long term funding shortfall of €2.3 trillion, and that the regulations may increase the costs of providing corporate loans by around 45-50 basis points and of specialised lending by around 60 basis points.

The ratings of the underlying projects will also drive capital that will be reserved and renewable projects are unlikely to achieve investment grade rating, therefore putting even greater demands on capital in green sectors.

Under the new lending conditions resulting from increased regulation in the financial sector, the inherent characteristics of much of the green economy are likely to make them difficult to attract scaled-up capital. As McKinsey (2010) notes, *'banks are likely to systematically review their capital allocation to each client segment and ensure that capital is preferentially allocated to segments that generate higher returns—adjusted for risk, capital, and funding costs—provided that these segments can be efficiently served by the bank.'* This operating environment will make diverting a substantial increase in debt capital towards some elements of the green economy very challenging: the technological immaturity/lack of track record, for instance, in the offshore wind sector[21], creates investment and operational risks that banks may well be unwilling to experience substantial exposure towards, despite the policies that have been put in place (or are in the planning process) to increase returns and improve certainty of return. A recent KPMG (2011) report highlighted that less than 5% of debt providers (including but not limited to banks) were intending to direct capital towards management and installation within the offshore wind sector, making it the least attractive of the fourteen sectors considered. It also reported that, even within the onshore wind sector (the most favoured sector for debt investors) *'anecdotal evidence suggests that lenders are becoming increasingly selective and are scrutinizing investment opportunities much more vigorously.'*

Two other challenges may limit the provision of bank debt to the renewable sector: a lack of opportunities to recycle capital and, within project finance lending, a shortage of skills. In terms of the former, there are relatively few opportunities for banks to remove loans from their balance sheet after the construction phase is complete, for instance, through sales of the assets to institutional investors (see section 4.1). This reduces the velocity with which capital can be recycled to new construction projects and, indeed, reduces the attractiveness of initially providing loans. In terms of the latter, project finance transactions are complex to structure and require sophisticated skills that are relatively rare in the market. Capital providers have indicated that a 50% increase in processing capacity – say from 6-7 deals a year to 10 deals a year – may take up to three years to implement[22].

As a result of these factors, without further intervention, the amount of bank debt available is unlikely to be sufficient to meet the UK's ambitions. For instance, Ernst and Young (2010) estimate that the amount of project finance available[23] that could be allocated to the low-carbon transition may be in the region of £1.2-£1.4 billion per annum[24]. The amount of debt that could be raised by the energy utilities – some of which is likely to be in the form of bank loans – is discussed further below.

Larger deals are particularly hard to finance. The difficulty of attracting debt into green projects has been proved by a recent offshore wind refinancing deal (signed in October 2009) which involved no less than fourteen banks to provide the level of debt required and was oversubscribed (GIB Commission, 2010). Thus even though offshore wind is considered attractive, the large deal sizes mean that projects are harder and slower to finance. By extrapolation, the same argument would apply to all green sectors, signalling the need for a GIB to provide the level of finance and assistance currently not provided by markets.

[21] According to Vivid scenarios, offshore wind constitutes 25-39% of total green investments up to 2020.

[22] Personal communication to Vivid Economics in the course of project due diligence.

[23] This includes both debt and equity, with the former likely to be larger.

[24] This estimate is caveated with the statement that: '*Impact of new banking regulations and consequent capital impact on banks' project lending volume is not factored into this analysis'*.

4.4 Bonds

Conventional bonds have traditionally been a good way of raising infrastructure finance. As section 3 showed, firms in the green economy have tapped the bond market for around £6 billion a year on average in the last 10 years, with over 70 major issuances in the 2009 and 2010 alone. At the same time, the green sectors are only a small fraction of the highly liquid UK bond market (Eurosterling and gilts), which is currently valued at about £1.2 trillion – of which £700 billion are UK government gilts (Veys 2010).

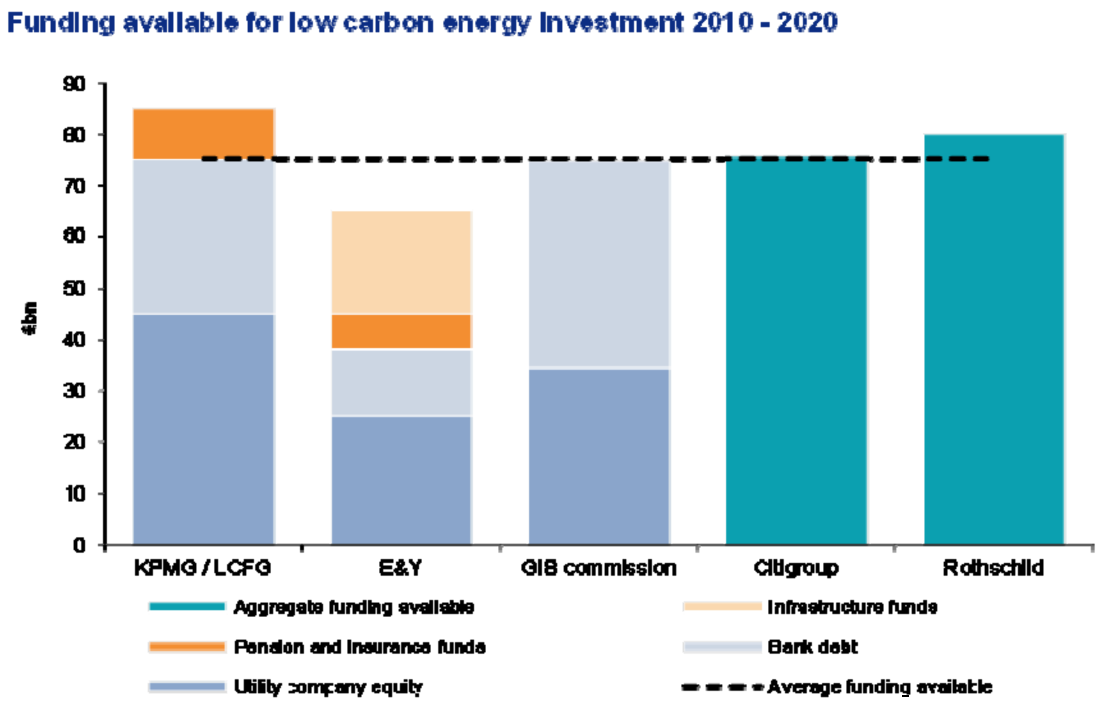
Green bonds may present some potential, but the concept is still only vaguely defined. At its simplest green bonds are conventional bonds where proceeds are used for green purposes. For example, the World Bank, the EIB and other public institutions have issued close to £2bn in green bonds, primarily to fund carbon reduction projects (Accenture 2011). This constitutes only a minimal departure from the way the green sector accesses the bond market now. A more sophisticated approach would involve bonds where the coupon is linked to environmental performance. The yield on a forestry bond, for example, may be higher if certain deforestation or sustainable forest management targets are met. However, the demand for such products or bonds where investors accept a lower return on environmentally-desirable investments is small.

Bonds may play an important role in refinancing the environmental loan portfolios of banks. As seen above, the limited ability to move loans off balance sheet is an important constraint to banks in their green lending. Asset-backed green bonds that securitise the green loans of banks may be an effective way of refinancing the banks' loan portfolios and preserving their capital adequacy ratios. According to Accenture (2011) up to €1.4trillion could be securitized Europe-wide in this way between 2011 and 2020. However, as previous experience with asset-backed securities shows, this would require careful structuring, a fair risk allocation and, above all, a clear understanding of underlying risks. While the GIB will not be able to leverage its own finance until at least 2015 it might play a role in facilitating the bond issuance of third parties, by addressing some of the market failures listed in section 4.14.1(risk aversion and lack of precedent in particular).

5 The case of UK electricity

Given its importance for the green agenda, this section analyses the financing gap in the electric power sector in more detail. A number of industry studies have looked at financing needs and capital availability in power generation. They suggest that utility balance sheets (excluding National Grid, which has committed to an investment of £14bn for the next five years, but not beyond) could support between £25 billion and 45 billion in low carbon investment up to 2020. Including additional sources of finance (i.e. bank debt to vehicles other than the utilities, infrastructure funds and pension and insurance funds) this could rise to £55-75 billion (in light of existing policies)[25]. However, with investment needs of around £110billion (see section 3) a considerable funding gap remains. Figure 11 summarises the existing evidence. More detailed (and slightly more conservative) estimates based on Vivid Economics (2011) are presented in figure 11.

Figure 11. **Up to £75 billion of additional power generation funding may be available, with about half coming from utility balance sheets**



Source: BIS analysis

[25] This figure needs to be treated with caution for two reasons; firstly NG capex is only out to 2016 and secondly the methodology for calculating the required investment in networks is changing from RPI-X to RIIO from 2013 and it is not know what impact this may have on investment.

The 'Big Six' UK power generating utilities are currently investing about £4 billion per annum. Since privatisation the principal sources of funding for new generation and networks have been the major energy companies. Analysis of their balance sheets and historical capital expenditure patterns shows that investment in generation assets by the 'Big Six' power generating utilities (Centrica, SSE, E.ON UK, EDF Energy, Scottish Power and RWE npower) has fluctuated between £2.7billion and £4.5 billion a year (see table 4).

Table 4. **Historically, power utilities have invested around £4 billion a year**

Year	Annual investment(£bn)
2007	2.7
2008	3.8
2009	4.5
2010(Q1+Q2)	2.1

Source: ONS (DECC EMR Consultation Paper)

The 'Big Six' are unlikely to free up more than an additional £2 billion a year, or £20 billion until 2020, to finance green investment in the power sector. Table 5 depicts the incremental capital that the 'Big Six' might invest from future cash flow and additional debt, while continuing the same level of capex, interest payments and dividends.The lowest estimate was derived from the 'business as usual' free cash flow that the businesses currently generate, taking into account normal levels of capital expenditure, interest payments and dividends. This is the free cash flow which could be used either for capital investment, to repay debt or to increase dividend payments. It amounts to perhaps £16.4 billion up to 2020. This rises to maybe £17.1 billion when factoring in the ability to raise a certain amount of additional debt without significant credit downgrades (netting off additional interest payments). Substantially higher figures are possible only if utilities reduce existing capex in favour of green investment (up to £54.2 if all capex were green) and/or change their dividend policies (up to £75 billion). These last two cases are not considered realistic.

These estimates are inevitably uncertain. They require careful judgement about future cash flows and the amount of additional debt that could realistically be raised. The estimates are conservative in that they assume no growth in operating cash flow. Past performance was simply extrapolated.

The ability of utilities to invest more is constrained by three main factors. Investment decisions are limited by:

- the need to maintain a balanced portfolio to limit the risks to the company
- the need to avoid a downgrade in credit rating, which might arise from excessive debt;
- limits to the support parent companies are able to provide; and
- an assumed unwillingness or inability to raise new equity.

For example, our analysis assumes that only Centrica, SSE and E.ON UK raise additional debt. The other companies have gearing (which is a measure of indebtedness) above 50% which suggests raising additional debt would be problematic if assessed on a 'stand-alone' basis, i.e. without parent company support.

Some of these constraints may be overcome. In practice the foreign-owned utilities might increase borrowing from parent companies without the parent suffering major credit downgrades, as the UK is only part of overall group activities and revenue. Moreover, while the initial investments may be financed by utility equity it may be possible to 'gear up' once an asset (say, an offshore wind farm) has been constructed and is generating stable cash flow. Under one model in the long-term, the financial structure of offshore wind could be approximately 20% utility equity; 20% equity from other sources such as pension funds, infrastructure funds etc., and the remaining 60% as debt. Once operating, Vivid Economics estimates this structure could release an extra £10 billion in utility equity over a 10 year period.

But we cannot be sure that additional funds would be invested in low-carbon energy or indeed in the UK. Individual sectors, such as offshore or onshore wind, will need to compete for the additional available capital with other investment opportunities – both inside and outside the green economy, and within and outside the UK. Investment decisions will depend on the relative attractiveness of these options, balanced by the need to invest in existing, proven infrastructure. Furthermore, even if the parent company would be willing to invest a large amount of money in the UK, it might not end up doing so given the requirement to maintain a balanced portfolio.

Table 5. **Additional capital investment (beyond current capex) by the Big 6 utilities is likely to be less than £20 billion out to 2020**

£m	Total	Centrica	SSE	E.ON UK	EDF Energy	Scottish Power	RWE npower
With no additional debt	16,411	9,742	(999)	5,650	30	989	(2,442)
Including additional debt	*17,691*	*10,542*	*(599)*	*6,130*	*30*	*989*	*(2,442)*
Including all CAPEX (not just that in excess of 'business as usual')	54,222	16,980	8,575	11,130	8,040	7,609	1,888
Assuming no dividends	75,289	23,495	14,760	13,530	9,607	11,509	2,388

Notes: Figures in brackets denote negative numbers – the total is derived by adding up positive figures only. The row in italics is the scenario discussed in the text.

Source: Vivid Economics (2011)

6 The role of the GIB

This section makes the case for a public finance institution, like the GIB, as part of the UK's green policy mix. It uses evidence from other, similar organisations to suggest that MEIP interventions by the GIB could play an important role in implementing the UK's climate change objectives. Evaluation reports from these organisations highlight the central role that public financial institutions already play in financing the emerging green economy.

The section recapitulates the need to step up delivery and briefly reviews the experience of four other public finance institutions. It finishes by making the case for a green investment bank. The four organisations reviewed are:

- the World Bank;
- the European Investment Bank (EIB);
- the European Bank for Reconstruction and Development (EBRD);
- the Kreditanstalt für Wiederaufbau (KfW).

6.1 The need to step up green delivery

Policy and finance delivery has to step up not just in the UK but EU-wide. A recent progress review on the EU's renewable energy targets concluded that:

> *'**The financing of the growth of the renewables sector needs more attention*** [original emphasis]. *Striving to compete with incumbent energy companies, technologies and traditional infrastructure, with fossil fuels and nuclear power still receiving four times the level of subsidies*[26]*, renewable energy is often more expensive than traditional sources. However the traditional sources must be replaced, if we are to enjoy the net benefits of a clean and sustainable energy system'* (European Commission 2011c).

The European Commission considers the EU's financial support for renewable energy to be relatively low. It calls for '*a reorientation of EU budget priorities ... both in terms of more focused use of existing instruments and in developing new European instruments*' (European Commission 2011c). This provides the context for the UK's own measures to improve green infrastructure (not just renewable energy) finance.

The UK debate reflects the EU-wide concerns; in particular, the independent Committee on Climate Change has repeatedly called for a step change in low-carbon delivery. The latest progress report (CCC 2011a) found that the UK is on track to meet its first and second carbon budgets. However, this is primarily due to the recession, which has temporarily reduced industrial output and energy demand, and thus carbon emissions. Moreover, the investment profile suggested for sectors such as wind and building efficiency is relatively flat during the first budget period but will require a sharp acceleration in delivery over the coming

[26] This is not the case in the UK.

decade. The Committee on Climate Change has therefore repeatedly called for a step change (CCC 2009, 2010b, 2011a).

A step change is required both in terms of policy implementation and investment. The Committee on Climate Change has developed a comprehensive indicator framework to track progress towards a low-carbon economy. The framework covers outcomes (e.g., emissions, energy use, carbon intensity), the investment decisions that drive outcomes and the policies that influence investment decisions. A step up is required along all the stages in this causal chain, including measures to facilitate and support access to capital.

6.2 Precedents for the use of public financial institutions

Public financial institutions have been used successfully before to deal with (temporary) spikes in financing needs. Although there are currently no institutions with an explicit green investment mandate, there are a number of organisations that were set up to boost access to finance at a time of high capital needs. Some of them have since entered the area of green investment. Particularly instructive are the cases of the World Bank, the European Investment Bank (EIB), the European Bank for Reconstruction and Development (EBRD) and Germany's Kreditanstalt für Wiederaufbau (KfW):

- *The World Bank:* The Bank was set up in 1944 to help finance the post-war reconstruction, although it now focuses on developing countries. Nearly three quarters of the loans made between 1946 and 1963 were for physical infrastructure projects, especially for transport, electrical power, ports and harbours and industrial plant. Today the Bank's remit is broader and includes fields such as human development, private sector development and environmental protection. However, infrastructure still represents the largest area of financial engagement (30% of its financing between 2008 and 2010). Within the World Bank Group the International Bank for Reconstruction and Development (IBRD) provides non-concessional loans to governments, the International Development Association (IDA) offers highly-concessional credit to the poorest countries, the International Finance Cooperation (IFC) finances the private sector and the Multilateral Investment Guarantee Agency provides political risk insurance.

- *The EIB*: Set up in 1958, the original vocation of the EIB was to serve as a capital provider for the 6 constituting countries of the EEC by facilitating loans pertaining to the development of their economies. The early interventions were designed to reduce the shortcomings of the different national capital markets and to offer long-term credits necessary for the regional and industrial development, as well as trans-European infrastructure. The EIB has since grown to become the largest multilateral lending institution in the world. Financing infrastructure-related projects accounted for about half of the EIB's total lending in the European Union in the period 2005-09.The bank primarily provides loans, for which it requires adequate security, for example, through a bank or parent company guarantee.

- *The EBRD:* Set up in 1991, EBRD's mandate is to support the transition to a market economy in former communist countries. Since 2011 EBRD also supports countries in the southern and eastern Mediterranean. In 2010 the bank supported close to 400 projects, most of them in the private sector and all on commercial terms (EBRD 2011). Sustainable energy lending accounted for almost a quarter of the business volume. EBRD has strict operational criteria to prevent it from crowding out private finance -each project has to meet additionality and sound banking tests. 'Sound banking' is monitored by the credit department, which assesses credit risks and ensures the financial terms are commensurate with the risks taken. The 'additionality' test confirms that terms are on a par with private sector conditions and no equivalent private financing was available. Most loans are syndicated to provide an independent 'market test'.

- *KfW:* Founded in 1948, the KfW initially supported Germany's reconstruction, with primary funding from the Marshall Plan. KfW loans were offered for the reconstruction of the energy supply system, and for the repair of homes and other buildings damaged in the war. From the second half of the 1950s the bank financed environmental protection measures. Between 2006 and 2008 KfW committed €16 – 19 billion annually to environmental and climate protection projects, on both MEIP and subsidised terms. Of these €8.1 billion was in support of energy efficiency projects and €5.3 billion to promote renewable energy (2008 figures). A large proportion of these funds were for projects in Germany, explicitly aligned with the German Government's 'Integrated Energy and Climate Change Programme'.

The experience of these organisations shows that public finance institutions can be an effective way of sharing risk and overcoming financing constraints. In their own way, the four organisations have all been successful in tackling financing constraints in situations where investment demand outstrips the supply of capital, such as during post-war reconstruction, during post-communist transition and in the case of infrastructure, renewable energy and energy efficiency investment. They have also proved effective in providing finance on a sustainable basis without necessarily resorting to subsidies (although some programmes do have subsidy elements to overcome market failures). Four lessons in particular stand out for the GIB:

- *Neither public nor private capital alone is sufficient to deliver enough infrastructure finance.* The World Bank's Sustainable Infrastructure Action Plan (World Bank 2008) notes that an important lesson realised during the past two decades has been that neither the public nor the private sector alone can meet the access, quality, financing, and policy gaps for infrastructure. A recent report by the World Bank's independent evaluation group also notes that the Bank's involvement in infrastructure projects has on average been more successful than its interventions in other sectors of the economy (IEG 2011).

- *Public capital need not crowd out private investment.* The experience of all four organisations, but particularly those with a private sector focus (EBRD and IFC, the private sector arm of the World Bank)shows that public investment is more likely to leverage than crowd out private investment. However, operational arrangements have to be in place to ensure and monitor adherence to market economy investor principles on an on-going basis (an example would be EBRD's 'additionality' criteria). An independent World Bank evaluation concluded that the majority of IFC's infrastructure projects contribute to broader private sector development (IEG, 2011). EBRD evaluation reports similarly attest that EBRD has been successful in leveraging private finance and transforming the sectors in which it is active[27]. A 2005 report on the role of the EIB in promoting public private partnerships noted that in addition to the benefits that the Bank's intervention brought in lowering all-in financing

[27] See the results of the latest strategic portfolio review, http://www.ebrd.com/pages/about/policies/spr.shtml.

costs, and improving loan terms and repayment profiles, some of the ancillary benefits brought by its interventions, included: *development of third party funding, … the willingness to stay aboard for the long-term, and political effects'* (EIB, 2005).

- *Public financial institutions are important players in supporting the low-carbon transition, but at the moment they do not have sufficient scale.* All four organisations provide active support for green projects that is instrumental in implementing climate objectives. Over 85% of renewable energy loans and assistance by the EU is channelled through the EIB (€8.4 billion out of € 9.8 billion during 2007-09, European Commission 2011c). However, comparing the current support from the EIB with investment needs in the green sectors highlights the magnitude of the funding gap. UK green investment needs per annum are much higher than the total EU-wide EIB loans over three years. During the 2009 recession, the EIB provided substantial support for the UK renewable sector, but the amount – £700 million in EIB match funding to RBS, Lloyds and BNP Paribas Fortis (Holmes and Mabey, 2010) – is again small relative to future needs.

- *Public finance institutions need to select their interventions carefully.* The products offered by public finance institutions need to be designed to share risks appropriately and target critical market barriers. A fair amount (but not all) of this can be done on an MEIP basis. The World Bank's independent evaluation group concluded that '*Long-duration loans are critical for support of renewable energy. Guarantees… could be increasingly important for renewable energy as investors seek reassurance that favourable policies will be maintained over the long run'* (IEG 2010). IEG also notes that providing long-duration loans is likely to have a much bigger impact on project bankability than the purchase of carbon credits, at current carbon prices. Although this partly reflects the challenges associated with project-based crediting in the developing world, it also demonstrates the potential catalytic impact of public finance. A 2008 report examining the role that the EIB had played in supporting renewable energy concluded that: '*a number of promoters commented that engaging with the EIB had the effect of drawing in other sources of finance, particularly where new and innovative technologies were being developed and potentially viewed as requiring a higher risk rating. The role of the EIB in this case provides some level of comfort to other lenders, enabling the projects to receive additional funding'* (EIB, 2008).

6.3 The case for a green investment bank

The experience of similar organisations suggests that, in addition to providing subsidised funding to certain sectors, MEIP interventions by the GIB could play an important role in implementing the UK's climate change objectives. Evaluation reports from organisations like EIB and the World Bank highlight the central role they already play in financing the emerging green economy. The EU for example channels a striking 85% of its renewable energy support through the EIB (European Commission 2011c), although this covers both MEIP and state aids interventions. Although this is not sufficient to close existing funding gaps (see section 3), it suggests that rather than crowding out private finance a well-managed GIB could leverage additional private investment.

The GIB is part of a much broader set of measures to create a green UK economy. The UK has put in place an array of policies to facilitate decarbonisation and green growth. Each measure is aimed at a particular aspect of the green growth challenge. For example, there are specific measures to put a price on carbon (EU ETS, climate change levy, carbon price support), support new technologies (renewable energy obligation, renewable heat incentive, feed-in tariff), provide investor confidence (electricity market reform), internalise local externalities (landfill tax, fuel duty), overcome behavioural barriers (CRC Energy Efficiency Scheme, supplier obligations), address information imperfections (DECs, EPCs)and facilitate access to finance (Green Deal, GIB). Within this broader policy framework, the GIB's mandate would involve:

- 'Identifying and addressing market failures limiting private investment in carbon reduction activities (high priority);
- Providing coherence to public efforts to support innovation in relation to climate change by rationalising existing Government-established bodies and funds (high priority);
- Advising on financing issues in central and local government policy making' (GIB Commission, 2010).

This combination of measures, including the GIB, is necessary to unlock the high levels of investment needed. The transition to a green economy will require investments in the order of £220 - 330 billion over the next decade. This constitutes a step change compared to past investment trends. Firms in the green economy typically raise no more than £18billion a year for all their financing needs, including acquisitions, debt refinancing, working capital as well as investment. They spend perhaps £6-8 billion on green projects. The UK as a whole dedicates over £200 billion a year to investment (gross fixed capital formation). However, redirecting significantly more capital to the green economy is not straightforward. There are barriers related to the risk profile of green investment, the risk appetite among investors, the capacity of borrowers to absorb additional finance and the availability of project finance skills. The GIB, as part of an array of complementary policies, can help to overcome them, for example by de-risking and enabling project finance (e.g. first of a kind offshore wind projects).

The UK's green economy goals are part of an EU-wide (and increasingly global) ambition for green growth and sustainable development. Most of the UK's green economy goals are statutory, enshrined in legislation like the 2008 Climate Change Act. Many of them implement legally-binding EU directives on water, waste, climate change and renewable energy, and reflect a shared vision among European leaders for environmentally, socially and economically sustainable development. They respond to global expectations that the UK and Europe must play a leadership role in combating climate change and lead the global decarbonisation effort.

7 References

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Annex: Historic and future green investment

This annex details the sources and assumptions used to construct the historic and future green investment requirements reported in section 3.1.

Past investment

For all renewable electricity generation technologies (offshore wind, onshore wind, tidal, PV and biomass), investment is assumed to be equal to the change in net generating capacity reported in table 7.4 of the Digest of UK Energy Statistics (DUKES), (DECC, 2011c). This is equivalent to assuming that there is no retirement of renewable capacity in the period 2006-2011. For each of these technologies, the following additional assumptions are made:

Table 6. **Cost and phasing assumptions for historic renewable electricity generation investment**

Technology	Cost (£m/MW, nominal)	Source	Years in construction	Assumed capex in each year of construction
Offshore wind	£2.0m/MW in 2006 and 2007, £3.0m/MW in 2008 - 2010	BWEA (2009)	2	50% in each year
Onshore wind	£1.3m/MW in all years (assume historic capex costs same as current)	GL Garrad Hassan (2010)	1	all in one year
Tidal	£7.8m/MW	RenewableUK (2010)	2	50% in each year
Solar PV	£4.4m/MW	Element Energy (2009a)	1	all in one year
Biomass	Landfill gas - £1.4m/MW Sewage gas - £3.6m/MW Municipal solid waste combustion - £5.1m/MW Dedicated biomass (assumed to apply to animal and plant biomass - £2.4m/MW	ARUP (2011)	3	33% in each year

Source: Vivid Economics

For offshore transmission investment, the value of investment is approximated by the transfer value for each project reported for the purposes of the offshore transition tenders (RBC Capital Markets, 2009 and Ofgem, 2011). For projects where construction is completed[28], the trajectory of investment is assumed to follow the same profile as the growth in offshore transmission capacity over the period 2003-2010. For the remaining

[28] Barrow, Robin Rigg East and West, Gunfleet Sands I and II, Ormonde, Thanet, Walney I.

projects in the first tender round[29], we assume that three quarters of ten transfer value has been spent, spread equally over each year in the period 2008-2010. For the Transitional Round 2 Tranche A projects[30] we assume that 50% of the transfer value has been invested, spread evenly over 2009-2010. For the Transitional Round 2 Tranche B projects[31], we assume that one quarter of the transfer value has been invested, all in 2010.

Historic data on household energy efficiency investment is taken from a number of sources:

- for 2005-2008 from an evaluation of the Energy Efficiency Commitment, 2005-08 (Eoin Lees Energy, 2008), with the total investment reported assumed to be spread equally across each year;
- for 2008-2011 from the Regulatory Impact Assessment amending the CERT (DECC, 2009) also assumed to be spread equally across all years;
- for 2011-2012 from the Regulatory Impact Assessment extending the CERT to 2012[32] (DECC, 2010a).

For the remaining sectors where there has been investment, we use the following sources:

- for water from data provided by Ofwat for the England and Wales water sector (Ofwat, 2010c);
- for rolling stock from National Rail Trends published by the ORR (2011);
- for waste from Defra (private communication), but data is only partial.

For industrial energy efficiency there is no reliable historic data. We assume that historic investment in the period 2007-2010 has been equal to the low end estimate of investment in 2011.

We assume there has been negligible investment in the period 2007-2010 in renewable heat, electric vehicle infrastructure, smart grids, nuclear, CCS or smart meters. We used interim data on waste infrastructure investment.

[29] Sheringham Shoal, Greater Gabbard and Walney II.

[30] London Array, Lincs and Gwynt y Mor.

[31] Humber Gateway, Race Bank, West of Duddon Sands.

[32] The investment figures reported in this document are in present value terms. However, as the discounting of investment is only over two years, it is close to the cumulative investment for the same period.

Future investment

Most of the figures are taken from Vivid Economics (2011) converted into nominal prices using projections for CPI. In addition, we include onshore wind, domestic energy efficiency and biomass electricity generation.

Offshore wind

The DECC authored document '2050 Pathways Analysis' (DECC 2010b) sets out four possible scenarios for the development of the offshore wind industry in the UK:

- Level 1 assumes a build rate of 0.5 GW/year, which is greater than the historic rate but less than the 0.65 GW/year which the current supply chain was estimated to be capable of in Pöyry (2009). A total of 8GW are built under this scenario but it is also assumed that sites are not replanted when the turbines are decommissioned after their standard 20 year life cycle.
- Level 2 assumes that supply grows in line with the 'high feasible' scenario of the Pöyry report to 2020 and then increases to 3 GW/year from 2021. The 'high feasible' scenario sets out supply chain capacities of 350 MW in 2008; 700MW in 2010; 1225 in 2014; 1,400MW in 2015; 1,750MW in 2017; and 2,275MW in 2020.
- Level 3 assumes that the supply chain grows significantly to 2017, with a build rate from 2017 above the supply chain growth in the 'high feasible' scenario of the Pöyry report. This build rate would continue to increase up to 5GW/year by 2025. Under this level, around 25 GW of installed capacity would be achieved by 2020.
- Level 4, like level 3, assumes a rapid build rate to 2020 and expands further to 7GW/year after 2025.

This would lead to market timings as in table 7 below:

Table 7. **Estimates for the size of the offshore wind industry, in £billions (2011/12 prices)**

£bn	2011	2012	2013	2014-16	2017-21	2022-26	2027-31
Level 1	1.6	1.6	1.6	4.9	8.1	4.9	0
Level 2	2.3	2.8	3.4	14	36	49	49
Level 3	2.3	3.7	5.1	24	67	81	81
Level 4	2.3	4.3	6.3	31	93	113	113

Source: Vivid Economics analysis of DECC (2010b) and Pöyry (2009)

Industrial energy efficiency

The data quality on the UK energy efficiency opportunity is insufficient to provide a rigorous assessment of the market size for energy efficiency investment. However, DECC (2010b) and AEA (2010)[33] gives a lower bound estimate of £700m of investment in the period 2012-2020; the ENUSIM model and AEA (2010) gives an upper bound estimate of £3bn of investment in IEE over the same period. In table 8 below showing the timing of investments, it is presumed that any investment in this period is spread uniformly across the 9 years in question.

Table 8. **Estimates for industrial energy efficiency in £billion (2011/12 prices)**

£bn	2011	2012	2013	2014-16	2017-21	2022-26	2027-31
Lower bound estimate	-	0.08	0.08	0.24	0.31	-	-
Upper bound estimate	-	0.33	0.33	1	1.33	-	-

Source: AEA (2010), DECC (2010b), ENUSIM

Non-municipal commercial and industrial waste

The estimate for the investment potential of this sector was compiled by DEFRA in a personal communication, which asserted that the sector requires an additional investment of £1.2 billion by 2020 in commercial and industrial waste management. This capex requirement is made up of around 60 material recovery facilities at £20 million each.

Table 9. **Estimates for waste in £m (2011/12 prices)**

£m	2011	2012	2013	2014-16	2017-21	2022-26	2027-31
Market size	133	133	133	400	400	0	0

Note: the investment could be higher if demand is higher or more expensive advanced technologies are used, and the time period could also be more extended

Source: Defra and Vivid Economics

[33] This figure is derived from Appendix 1 of AEA (2010), taking the core basic scenario and realistic potential

Biomass

The profile of future biomass investment is taken from the National Renewable Energy Action Plan (DECC 2010c)[34]. This identifies growth in solid biomass capacity, at the same time that capacity of biogas plants is expected to fall, and strips out the expected growth in CHP. In terms of non-CHP solid biomass capacity, as DUKES reports that the existing capacity of municipal solid waste combustion facilities, animal biomass facilities and plant biomass facilities is greater than the capacity foreseen in the Plan until 2014, we assume that no new facilities come on stream until 2014. We assume growth in CHP in line with the Action Plan.

The costs of biomass plant are taken from ARUP (2011). We assume that 50% of the new non-CHP biomass facilities are free standing biomass plant and 50% of the capacity is municipal solid waste capacity. Median cost estimates are used. It is assumed that biomass plants take three years to construct and that the investment is phased equally across each year.

Table 10. **Estimates for biomass in £billions (2011/12 prices)**

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Market size	0.08	0.27	0.55	0.87	1.10	1.21	1.35	1.53	1.79	2.09

Source:Arup (2011)

Onshore wind

The profile of future onshore wind investment is taken from the DECC Pathways analysis (DECC 2010b). The minimum scenario is the build-out assumed in Level 2 in this analysis and the maximum scenario is the build out assumed in Level 4. We assume that the cost of onshore wind investment is £1.3m/MW – as reported by GL Garrad Hassan (2010) for projects between 20 and 50 MW - and that this remains constant in real terms throughout the period 2011-2022. We assume that construction of onshore wind capacity takes one year.

Table 11. **Estimates for the size of the onshore wind industry, in £billions (2011/12 prices)**

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Lower bound estimate	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Upper bound estimate	1.98	1.98	1.98	1.98	1.98	2.73	2.73	2.73	2.73	2.73

Source: DECC Pathways analysis (DECC 2010b)

[34] The Pathways analysis used for the future scenarios for other renewable electricity generation technologies does not identify biomass electricity generation capacity separately.

Domestic energy efficiency

Domestic energy efficiency figures were obtained from DECC (private communication). The figures represent capital costs (£m) of installing insulation measures under the Green Deal and ECO. A few things to note:

- These cost are the direct installation costs and do not include assessment, admin costs, etc.

- They cover the insulation measures installed under Green Deal, and under the ECO for different levels of carbon target and Affordable Warmth target.

- The do not include the cost of heating measures installed under Affordable Warmth.

- These numbers are preliminary, and will change as the analysis is refined.

- The level of the carbon target is still under discussion and the figures in table 12 are purely illustrative.

- The profile of costs (which peak in 2015-16 and then drop off) is largely a function of the modelling approach (in which a fixed per cent of untreated households undertake renovations each year, leading to a decline in absolute annual sales as potential is used up).

Table 12. **Estimates for domestic efficiency in £billions (2011/12 prices)**

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Lower bound estimate	2.07	2.36	0.38	0.52	0.67	0.74	0.80	0.82	0.76	0.74
Upper bound estimate	2.07	2.36	1.06	1.17	1.43	1.51	1.49	1.33	1.25	1.27

Source: Private communication with DECC

Renewable heat estimates

The Department for Business, Innovation and Science (BIS) has estimated a capital expenditure profile for renewable heat. Its estimates refer to ‘capital expenditure required in addition to the counterfactual costs if the heating continued to be generated by fossil fuel source needs’[35].

The estimates reported in BIS’ internal paper are cumulative and in 2008 prices:

– the average annual capital expenditure is £247m for domestic and non-domestic combined;
– for non-domestic only, the average annual capital expenditure is £142m.

The estimates for the non-domestic sector only based on BIS’ work are adjusted to a common price base, 1st April 2011, and are presented in table 13 below. No estimates are included for the domestic sector because it

[35] The internal BIS paper (‘Work stream 1: Policy ambition and market failures – Proposed Template for Market Failures’) states that the estimates are based on “a potential uptake scenario as presented in the February 2010 RHI consultation. Current policy revisions (post CSR) are not reflected in the above numbers. Also actual financing needs are a result of the RHI and thus may be significantly different depending on the type and size of renewable heat deployment”.

is likely that the GIB would be financing non-domestic investments only. It is assumed that the average annual capital expenditure is added in each year, such that investment occurs at a uniform rate over the period.

Table 13. **Estimates for renewable heat capital investment in £billions (2011/12 prices)**

£bn	2011	2012	2013	2014-16	2017-21	2022-26	2027-31
Investment	0.2	0.2	0.2	0.5	0.8	0.8	0.8

Source: Vivid Economics analysis of BIS internal paper

Water supply estimates

The industry regulator, Ofwat, has set capital expenditure allowances for the period 2010–2015 (Ofwat 2009, page 66). These allowances refer to water companies operating in England and Wales although this does not affect the analysis presented in this report because the water utilities in Scotland and Northern Ireland are publicly owned and are therefore less likely to be in receipt of investment from the GIB. Table 14 lists the estimated capital expenditure profile. For simplicity, it is given an equal level of expenditure in each year. The level of capital expenditure in 2010–2015 is presumed constant in the years up to 2031.

Table 14. **Estimates for water supply and sewerage, in £billions (2011/12 prices)**

£bn	2011	2012	2013	2014-16	2017-21	2022-26	2027-31
Investment	4.7	4.7	4.7	14.1	23.6	23.6	23.6

Source: Ofwat (2009)

Electrical vehicle infrastructure estimates

According to Element Energy Limited (2009b) in a report written for the Committee on Climate Change (CCC):

> *'the cost of an installed publicly available slow charge (low kW) post could range from £6,000 (current prices) to £1,000–£2,000 (at volume). A fast charge (>50kW) point could cost between £50,000–£100,000, depending on the necessity for upstream grid reinforcement'*

The same report highlights the scenario developed by the Committee on Climate Change in which around 45 per cent of car journeys (measured as car kilometres and forecast to be 508bn km by 2030) could be undertaken by electric vehicles. Capital costs are estimated at £5,574 for a public slow charge point falling to £2,574 with increased volume and £93,450 for a fast charging point.

The Parliamentary Office of Science and Technology (2010), asserts that there are currently around 250 charge points in London, mostly in car parks and that Transport for London is aiming for 25,000 charging points by 2015, of which 90 per cent will be workplace charges and 250 will be fast charge. Based on Element Energy Limited (2009b), 22,500 public slow charges by 2015 would cost approximately £20m per annum over 5 years and 250 fast charge points would cost approximately £5m per annum over 5 years. Estimates of demand for electric vehicles, and by extension electric vehicle infrastructure, are highly uncertain and the scenario below is based on expected investment by Transport for London and DfT.

Two possible scenarios are presented. The high scenario assumes that the level of investment from the Department for Transport remains constant after the current funding round expires in 2013, and then investment from both the department and Transport for London doubles every five years thereafter. The low scenario assumes that funding from the Department for Transport ceases in 2013 and resumes after a pause in 2015 and then increases by 50% every five years.

Table 15. **Estimates for electric vehicle infrastructure, in £billions (2011/12 prices)**

£bn	2011	2012	2013	2014-16	2017-21	2022-26	2027-31
High	0.031	0.044	0.044	0.18	0.53	1.1	2.1
Low	0.031	0.044	0.044	0.12	0.37	0.55	0.82

Source: Vivid Economics analysis based on Parliamentary Office of Science and Technology (2010) and Element Energy Limited (2009b)

Smart grids estimates

Ofgem has made £500m available in the 5 years from April 2010 for larger scale trials (DECC 2009a). In the scenario presented in table 16, investment in smart grids is £100m per annum in the years 2011–2015. However, it is likely this is a lower bound estimate as transmission companies have put forward plans for investment of £4.7bn by 2020 for refurbishment and expansion of their networks (DECC 2009a).

Table 16. **Estimates for smart grid investment in £billions (2011/12 prices)**

£bn	2011	2012	2013	2014-16	2017-21	2022-26	2027-31
Investment	0.1	0.1	0.1	0.3	-	-	-

Source: DECC (2009a)

Flood defences

In February 2011, the Department for Environment, Food and Rural Affairs announced the level of flood defence expenditure over the four years from 2011/12; there are no published figures for the years following this. However, due to the rising frequency of flooding events it would be a reasonable assumption to use expenditure in the coming years as a lower bound estimate for ongoing expenditure, as set out in table 17.

Table 17. **Estimates for flood defences in £billions (2011/12 prices)**

£bn	2011	2012	2013	2014-16	2017-21	2022-26	2027-31
Investment	0.5	0.5	0.5	1.5	2.6	2.6	2.6

Source: Defra and Vivid Economics

Rolling stock

The following rolling stock projects are in procurement:

- Thameslink (c£1bn in 2011 and c£1bn in 2012)
- Intercity Express (£1.6bn in 2011 and £1.2bn in 2013)
- Crossrail (c£1bn in 2012/13)[36]

With respect to Thameslink, the Department for Transport expects the first passenger trains to come into operation in February 2014 and the fleet introduction to be completed by December 2017/18 (DfT 2008). This suggests a build time which requires investment to be spread over at least three years. We have as such assumed that all investment is spread over three years from its start date for the purposes of table 18.

Table 18. **Estimates of future investment in rolling stock, in £billions (2011/12 prices)**

£bn	2011	2012	2013	2014-16	2017-21	2022-26	2027-31
Investment	0.9	1.5	1.9	1.5+	-	-	-

Source: Vivid Economics analysis of DfT data

We have also not provided data past the 2014-16 period as much of this investment in rolling stock will be due to High Speed 2, the information for which is yet to be announced.

Tidal range estimates

DECC's '2050 Pathway Analysis' describes tidal range technology as using '*the height difference in water levels caused by the tide to generate electricit*y' (DECC 2010b, page 195). The Pathway Analysis refers to four scenarios as follows:

- No capacity. The current situation persists.
- One of the three sites—Mersey, Solway and Severn—is completed by 2020, another by 2030 and a third by 2050. The indicative capacities are Solway (250–300 MW), Mersey (around 400 MW) and Severn (600–1,000 MW).
- 800 MW is operational by 2020 and a medium Severn Estuary scheme (3.6 GW) operational by 2030.

[36] Information received in a personal communication from the Department for Transport.

– All potential capacity, approximately 20 GW, is developed by 2050, with 3.3 GW by 2020 and a further 7.2 GW by 2030[37].

Capital cost estimates are reported in the DECC (2010b) Annex A, with central estimates of £2,600 per kW for 2020 and the same cost for 2030 (2009 prices). Assuming that the first project will commence in 2014, that projects will be evenly spaced and that projects will take three years to complete, the annual costs of the capital program are set out below.

Table 19. **Estimates for tidal range in £billions (2011/12 prices)**

£bn	2011	2012	2013	2014-16	2017-21	2022-26	2027-31
Level 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Level 2	0.0	0.0	0.0	0.8	0.0	1.1	0.0
Level 3	0.0	0.0	0.0	1.1	1.1	10.1	0.0
Level 4	0.0	0.0	0.0	4.7	8.7	10.1	10.1

Source: DECC 2010b

Wave energy and tidal stream

'Wave energy ... can be captured by wave conversion technologies to provide power. Tidal stream technologies harness the energy from the tides through the sheer velocity of the currents turning the blades of an underwater turbine (the majority of turbine designs are not dissimilar to a submerged wind turbine)' (DECC 2010b, page 201).

The Pathway Analysis refers to four scenarios as follows:

- Level 1 - no capacity. The current situation persists.
- Level 2 – wave: 300 km of 8 MW per km in the Atlantic (2.4 GW); tidal stream: 2 GW. No deployment until 2030. Total capacity of 11.5 GW by 2050.
- Level 3 – wave: 600 km of 8MW per km in the Atlantic (4.8 GW); tidal stream: 9.4 GW. Deployment begins in 2020. Total capacity of 2 9GW by 2050
- Level 4 - wave: 0.8 GW by 2020 and 900 km of 10 MW per km in the Atlantic (9 GW); tidal stream: 0.5 GW by 2020 and 21.3 GW. Deployment begins in 2014. Total capacity of 58 GW by 2050.

Capital cost estimates are reported in DECC (2010b) Annex A. For wave the central estimates are £2,380 per kW for 2020 and £1,097 per kW for 2030 (2009 prices). For tidal stream the central estimates are £2,043 per kW for 2020 and £1,239 per kW for 2030 (2009 prices). Assuming that the first project will commence in

[37] This is based on Mersey (620 MW), Welsh Grounds Lagoon (1,360 MW), Bridgewater Bay Lagoon (1,360 MW) Solway (7,200 MW), as per tables K1 and K2 of DECC (2010b), page 197.

2014, that projects will be evenly spaced and that projects will take three years to complete, the annual investment is set out in table 20.

Table 20. **Estimates for wave and tidal stream in £billions (2011/12 prices)**

£bn	2011	2012	2013	2014-16	2017-21	2022-26	2027-31
Level 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Level 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Level 3	0.0	0.0	0.0	0.0	0.0	1.2	1.2
Level 4	0.0	0.0	0.0	1.6	1.6	2.2	2.9

Source: DECC 2010b

Nuclear estimates

The DECC Pathway Analysis (DECC 2010b) discusses four potential scenarios or 'levels' for nuclear power:

- the first level assumes no new investment occurs due to planning and other delays;
- the second level assumes 1 GW of new capacity every year from 2014;
- the third level assumes 1 GW of new capacity from 2014 and then 3 GW of new capacity from 2025;
- the fourth level assumes 1 GW from 2014 to 2020, 3 GW from then to 2025 and then 5 GW per annum.

The central capital cost assumptions reported in the DECC (2010b), Annex A, are: £2,686 per kW for 2020 and £2,584 per kW for 2030 (2009 prices). In 2011 prices, this equates to approximately £2,900 per kW and £2,790 per kW respectively. Table 21 reports estimates based on the above.

Table 21. **Estimates for nuclear power in £billions (2011/12 prices)**

£bn	2011	2012	2013	2014-16	2017-21	2022-26	2027-31
Level 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Level 2	0.0	0.0	0.0	8.7	14.4	13.9	13.9
Level 3	0.0	0.0	0.0	8.7	14.4	25.1	41.8
Level 4	0.0	0.0	0.0	8.7	25.8	47.4	69.7

Source: DECC (2010b)

Carbon capture and storage estimates

CCS refers to the system for capturing, transporting and storing carbon dioxide. This section provides estimates of investment in CCS.

DECC's Pathway Analysis (DECC 2010b) discusses four potential scenarios or 'levels' for CCS as follows:

- the first level assumes that four demonstrations are commissioned by 2018 with the first one operational in 2015. These might have a capacity of around 2 GW;
- the second level is the same as the first, with in addition 1 GW/year built in the years 2021 to 2023, increasing to 1.5 GW/year in the years 2024 to 2027;
- the third level is the same as the second, with a completion rate of 2 GW/year from 2025;
- the fourth level assumes a completion rate of 3 GW/year from 2030.

The central capital cost assumption in DECC (2010b), Annex A, is £2,035 per kW for 2020 and £1,943 per kW for 2030 (2009 prices). In 2011/12 prices, this is £2,197 per kW and £2,098 per kW respectively.

Table 22. **Estimates for CCS in £billions (2011/12 prices)**

£bn	2011	2012	2013	2014-16	2017-21	2022-26	2027-31
Level 1	0.0	0.0	0.4	2.9	2.1	0.0	0.0
Level 2	0.0	0.0	0.4	2.9	1.1	6.3	15.7
Level 3	0.0	0.0	0.4	2.9	3.2	15.7	21.0
Level 4	0.0	0.0	0.4	2.9	3.2	15.7	23.1

Source: DECC (2010b)

Smart meters estimates

Smart meters refer to gas and electricity meters that can provide consumers and energy suppliers with more timely and more detailed estimates of energy use. The government published an implementation programme in March 2011. In total, it is expected that approximately 53 million meters will be replaced at a cost of £11.3bn for the domestic and small non-domestic sector (DECC 2011b).

The government wishes to complete the roll-out by 2019 (DECC 2011b, page 18). Assuming that the programme starts in 2014 and takes 6 years to complete, there would be annual capital expenditure of £1.9bn[38].

[38] Some utilities plan to replace 'dumb' meters due for replacement with smart meters from around mid- 2012 (see DECC 2011d, page 11). These investments occur before 2014 but no estimates of them are available

Table 23. **Estimates for smart meters in £billions (2011/12 prices)**

£bn	2011	2012	2013	2014-16	2017-21	2022-26	2027-31
Investment	0	0	0	5.7	5.7	0	0

Source: DECC (2011d)

Offshore transmission estimates

Offshore transmission refers to the infrastructure which carries electricity generated from offshore wind turbines back to land. There are two separate components to the total costs of offshore transmission. The first is the cost which will be incurred actually connecting the offshore turbines to the coast. The crown estate estimates that the total cost of this for phase three of offshore wind will cost £10.4 billion (The Crown Estate, 2009, page 4).

There is also the cost incurred by the electricity grid in having to extend or strengthen the network to the points at which the undersea cables make landfall. The Electricity Networks Strategy Group, which is chaired jointly by DECC and Ofgem, has estimated that £4.7billion is required to pay for the reinforcing of the transmission network to accommodate offshore wind and new nuclear (ENSG, 2009, page 22). The offshore component of this additional expenditure is estimated to be in the range of 21-35 GW which implies a cost of £2.2-2.6 billion for the strengthening of onshore networks for offshore wind generation.

A report for the Crown Estate contains an estimate of £10.4bn for offshore transmission in 2008 prices for round three of offshore implementation. This is based on total installed capacity of 26 GW (The Crown Estate, 2009, page 4).

In the estimates in table 24, the investment in the high scenario assumes investment being undertaken at a rate to complete it within 10 years. In the low scenario it takes until 2025.

Table 24. **Estimates for offshore transmission in £billions (2011/12 prices)**

£bn	2011	2012	2013	2014-16	2017-21	2022-26	2027-31
High	1.4	1.4	1.4	4.3	5.4	0	0
Low	1.1	1.1	1.1	3.3	4.8	3.1	0

Source: The Crown Estate (2009)

Photovoltaics estimates

The PV installed capacity in the UK increased from 10.9 MW in 2005 to 14.3 MW in 2006, 18.1 MW in 2007, 22.5 MW in 2008 and an estimated 26.5 MW in 2009 (DECC, 2010f, Chapter 7). The main policy driver for future solar PV installation is the feed-in tariff system which was introduced in April 2010. However, there has been a reassessment of the policy this year due to higher than expected building of large solar PV 'farms' (DECC 2011c). Table 25 includes estimates produced as part of this review, including those estimates that cater for the possibility that the review's findings are rejected.

Table 25. **Estimates for photovoltaics in £billions (2011/12 prices)**

£bn	2011	2012	2013	2014-16	2017-21	2022-26	2027-31
Scenario 1	1.3	1.2	1.3	3.8	7.1	8.2	8.2
Scenario 2	1.4	1.4	1.4	4.3	8.2	9.8	9.8
Scenario 3	0.9	0.9	0.9	2.8	4.7	4.7	4.7
Scenario 4	1	1	1	2.9	4.8	4.8	4.8

Source: DECC (2011c)

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Company Profile

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