Green growth:

how best to promote green investment

There is much debate about the need to tackle climate change, but will this have net benefits or costs for the economy? It is clear that there will need to be very substantial investment, but will enough of this investment be forthcoming and where will the finance come from? Are there areas of market failure which might justify government intervention, and what demand and supply side measures are open to government to stimulate investment?

On the demand side these can include such measures as a carbon price floor, feed in tariffs or renewable obligation certificates. On the supply side is intervention necessary to help increase the supply of finance for investment, and in the UK is there a case for a Green Investment Bank and what should its remit be?

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Executive Summary

Governments worldwide are seeking to promote policies which will promote a low carbon energy infrastructure. The scale of the challenge is immense. The electricity and heat generation sector is by far the largest emitter of greenhouse gases in Europe accounting for 25% of total greenhouse gas emissions. The European Commission estimates that the investment cost of the renewable energy target of 20% of total EU energy consumption by 2020 will be Euro 667 billion. In the UK, OFGEM estimates that the UK needs by 2020 around £200 billion in generation, electricity networks and gas infrastructure of which at least £110 billion would be needed in new generation and transmission assets in electricity – over double the rate of the last decade.

This report examines whether government needs to intervene in order that this investment is carried out, in terms of Research and Development (R&D) of green technologies but also in the terms of measures to promote investment in the commercialisation and deployment of low carbon energy infrastructure.

Economic analysis of why optimal levels of R&D may not happen argues that where new products are still 'immature' and are unable to compete on costs with market leaders, investment in R&D may be less than is optimal as firms cannot always recoup all of the profits that arise from the research. Hence government support to R&D may be justified because the social return to the R&D may exceed the private return to the company. Some low-carbon technology is clearly 'mature' and evidence shows that maturing renewables technologies costs are falling quickly, by an average of 10 per cent across most sectors in 2009, even in wind which is the most mature.

However those technologies which have extremely limited markets, because they are still new inventions without a set of firms and a pool of financing to scale them up (eg offshore wind) may result in less investment in R&D than might be optimal for society. The other potential market R&D failure may be in the deployment and scale up of new technology due to the uncertainty over the future profitability of one investment over another.

Whether a government wishes to invest to fill these gaps will depend partly on whether government wishes for industrial policy reasons to develop that particular sector, rather than to import the relevant technology from elsewhere. However if a particular technology is particularly well suited to a particular country there may be good reason to provide support to develop that technology to meet the low carbon infrastructure needs of the country. Hence in the case of the UK, where offshore wind and tidal power generation have some comparative advantage compared to other economies, there may be a case for support for R&D as part of the desire to see investment in low carbon infrastructure rather than simply for industrial policy reasons.

When considering whether government needs to intervene to secure the levels of investment in renewable technologies which are required to attain the EU renewable energy target for 2020, government can intervene on the demand and/or the supply side. The presence of a carbon price helps to stimulate the deployment of renewables and lower carbon alternatives. However the EU's Emissions Trading Scheme has failed to create a strong enough market signal and a carbon price which is far too low to stimulate the required investment. This has led to calls for a carbon tax or minimum floor price which have been included in the UK government's proposed energy market reforms. However a minimum carbon price alone will not lead to the necessary investment in renewables except at a very high cost to the consumer, and even then might lead mainly to investment in non-renewables such as nuclear.

Those countries which have been most successful at improving carbon emissions have acted over and above the EU Emissions Trading Scheme to create certain and higher prices for low carbon technology than high carbon technology. In Europe two main types of policies have been used – quantity based policies and price based policies. The renewables obligation certificate has been used in Belgium, the UK and Italy, whilst the feed in tariff has been used in France, Denmark and Germany and is now being proposed to be used across the board in the UK.

Feed in tariffs by creating price certainty have helped to promote investment by creating greater certainty for investors. However they have generally proved to be more expensive than where renewables obligations have been used. Given the speed with which investment is required to meet the EU renewable obligation by 2020 many countries, such as the UK, have little choice but to adopt a feed in tariff regime which is technology specific. Without this binding time constraint, using a fixed price approach to provide greater price certainty for investors would be likely to be less economically efficient than a fixed quantity approach of the type used with Renewable Obligation Certificates.

However even with the right price signals on the demand side there is still the need to ensure that there is the supply of finance necessary for the amount of investment required. Given the scale of investment in renewables (which is required at much higher rates than in the past) concerns have been raised that there may still be insufficient investment because of market failures in the supply of finance for investment.

The UK Green Investment Bank Commission, which reported in June 2010, argued that a number of market failures and investment barriers to financing low carbon infrastructure meant that a Green Investment Bank (GIB) should be established. It was proposed that the GIB's remit should include:

- Advising on financial issues in central and local government policy making;
- Providing early stage growth equity and investment
- Issuing green bonds to finance investment in infrastructure;
- Providing insurance products, long term carbon price underwriting and the purchase of completed renewable assets.

One of the principal areas where it was felt that there is market failure is in the supply of debt to large energy infrastructure projects. This is attributed to the unwillingness of banks, since the financial crisis, to provide long term debt finance of 20 years or more. Furthermore, the project bond market has largely disappeared due to the demise of the monoline insurers.

Proponents of the GIB suggest therefore that the bank should purchase and securitise project finance loans, financed through the sale of green bonds.

However there is evidence that market intermediaries are already starting to step in to marry up supply and demand for commercial projects through the introduction of a layer of subordinated debt into the project debt. Hence the market imperfection, arguably caused by the particular circumstances of the financial crisis and the resultant financial difficulties of the monoline insurers, looks as though it may be 'ironed out' before there has been a public sector response rendering the public sector intervention unnecessary. Moreover it is clear that the GIB would be on the Government's Balance Sheet and would benefit from an implicit, if not an explicit, sovereign guarantee and so there is a danger that it would both 'crowd out' other government expenditure and/or 'crowd out' private sector finance.

Supply side policies to encourage investment in energy infrastructure are in our view of less importance than demand side policies. Whilst imperfections in the market for finance for investment in energy infrastructure do exist, particularly post the financial crisis, there is not in our view a general problem of lack of finance for good, economic projects. There is some evidence that there may be a particular problem connected with project development/commercialisation risk for offshore wind projects due to the bespoke nature and scale of many of these projects. There may therefore be the need for government (or a government owned entity such as a GIB) to provide some project insurance in this phase of development of a project.

We are not convinced however that there is a more general problem of lack of financing capacity for green investment throughout Europe as some proponents of a GIB in the UK are suggesting. The staged approach to the formation of a GIB in the UK is an appropriate one with the development of new financing products (such as that being developed by Hadrian's Wall Capital) to deal with elements of construction risk, being kept under review in case a more proactive approach by Government and the GIB, such as the issuance of 'green bonds' is required.

1 Introduction

In the face of the challenge posed by climate change governments worldwide are seeking to promote policies which will promote a low carbon energy infrastructure. But will this be of substantial cost to the economy or will it be of benefit, and what role should Government play in both securing a low carbon economy and in trying to maximise the benefits or minimise the costs? In 2008 an OECD climate change report argued that any significant reduction in greenhouse gas emissions would 'not be either easy or cheap'.[1] By contrast the Carbon Trust, a body in the UK, seeks to advise businesses and policy makers on how they can 'harness the economic benefits [climate change] presents' implying that they see potential benefits from a low carbon economy.[2] So what are the potential costs of measures to mitigate climate change, are there potential benefits from it and how can we ensure we make the investment necessary to mitigate it?

This paper will begin by examining the scale of the challenge to mitigate climate change and the costs and benefits of doing so. It will then quantify the scale of the investment which is needed to meet the requirements for a low carbon infrastructure. We then consider the lifecycle of R&D, commercialisation and the deployment of new technologies. Having analysed what measures are in place to mitigate climate change, the paper then examines the case for government intervention to promote investment in R&D of green technologies. We then look at the benefits and disbenefits of different demand or supply side measures to promote investment in commercialisation and deployment of low carbon energy infrastructure. In particular, as an example of measures which governments can take to try

1 OECD, 'Climate Change Mitigation: What do we do?', 2008.
2 www.carbontrust.co.uk/policy-legislation/pages/default.aspx

to promote investment in a low carbon infrastructure, there is a focus on the role that the proposed GIB in the UK might play in promoting investment . Finally we conclude as to which measures are likely to be the most effective and economically justifiable in promoting green investment.

: 2 The scale of the climate change challenge for the economy

In his frequently cited review of the economics of climate change, Lord Stern used the assumption that stabilisation at 550 parts per million (ppm) of CO_2 would keep global warming to below two degrees celsius (which scientists believe is the threshold beyond which climate change becomes highly dangerous and unpredictable) as the basis for his estimates of the impact of climate change. The economic consequences of this, he calculated, would lie somewhere between a boost to the economy of 1 per cent of GDP and a 3.5 per cent cost.[3] However, since 2006 more evidence about the relationship between carbon concentration and global temperatures has been collected. Scientists have revised the upper limit for keeping the temperature rise below two degrees downwards: most estimates suggest that even if we keep greenhouse gases within 450 to 550 parts per million the chances of keeping global warming below two degrees are only 50:50. So, to give an evens chance of a two degree rise, we need to make world emissions peak at around 2020. And the earlier and faster they decline, the more the chances of meeting the two degrees target.[4] The International Energy Agency argues that the '450 scenario' (keeping greenhouse gases below 450 ppm) would require renewables to grow by 110 per cent by 2030, amounting to 22 per cent of primary energy and 37 per cent of electricity needs. The IEA estimates that this would cost $38 trillion between now and

3 N Stern et al, 'Review of the economics of climate change', HM Treasury, 2006.
4 UK Met Office, 'Are the emission pledges in the Copenhagen Accord compatible with a global aspiration to avoid more than 2°C of global warming?', July 2010; D Bowen and N Ranger, 'Mitigating climate change through reductions in greenhouse gas emissions: the science and economics of future paths for global annual emissions', LSE Grantham Institute, 2009.

2030, or 2 per cent of global GDP.[5] The economic evidence, then, suggests that sharply curtailing our carbon emissions is possible, but that it is more likely than not to affect growth adversely, the size of which is uncertain, but is, by most estimates, between 1 and 5 per cent of GDP per year. Whilst the consensus estimates are that there are economic costs of climate mitigation there are still significant commercial opportunities.

So what is the evidence of the effect of environmental regulation? Micro-economists analysing the impact of environmental regulation in the 1990s were surprised by the lack of correlation between higher regulation and firm profitability.[6] The loss of jobs in mining and utilities in industrialised economies were found to be more closely correlated with increased automation, wage competition and exchange rates than with environmental regulation.[7]

There are four ways in which environmental regulation and taxation has an impact on output, and by extension employment. First, new output and jobs are created, like the manufacturing of wind turbines, the retrofitting of buildings to make them more energy efficient, and R&D in new clean technologies. Second, some jobs are substituted, eg from fossil fuels to renewables and nuclear power. Third, some output will vanish – more stringent regulations on some carbon-intensive goods and services will render them uneconomic, and the companies which supply them will disappear. In addition the higher price of non-fossil fuels will adversely affect economic output and activity. Finally, some jobs will simply be 'greened': plumbers, electricians and builders will learn new skills to cut the carbon footprint of their products.[8]

The potential cost of adaptation is the product of two variables. First, governments must decide how quickly and to what extent they will enact policies to cut carbon emissions. This depends on governments' views of the potential costs of mitigation now,

5 International Energy Agency, 'World energy outlook', 2009.
6 A Jaffe et al, 'Environmental regulation and the competitiveness of US manufacturing: what does the evidence tell us?', Journal of Economic Literature, 1995; R Repetto, 'Jobs, competitiveness and environmental regulation: what are the real issues?', World Resources Institute, 1995.
7 M Renner, 'Low carbon jobs for Europe: current opportunities and future prospects', WorldWatch Institute, 2009.
8 C Martinez-Fernandez et al, 'Green jobs and skills: the local labour market implications of addressing climate change', OECD, February 2010.

compared with potentially higher costs in the future. Currently the EU plans a 20 per cent cut in emissions over 1990 levels by 2020. Lord Stern advocates faster and more severe cuts to keep us within the 2 degree target, proposing that the EU should move to 30 per cent by 2020.

Other economists have disputed this. Harvard's Martin Weitzman argues that "the *Stern Review* consistently leans toward (and consistently phrases issues in terms of) assumptions and formulations that emphasize optimistically low expected costs of mitigation and pessimistically high expected damages from greenhouse warming."[9] Yale's William Nordhaus has long advocated a climate change 'ramp', arguing that "efficient or 'optimal' economic policies to slow climate change involve modest rates of emissions reductions in the near term, followed by sharp reductions in the medium and long term."[10]

The problem is that the risks are potentially large, but extremely difficult to quantify. In response to the debate between Stern and his critics, Martin Wolf of the Financial Times argues that because the risks are so great and the chances of the worst-case scenario happening are unknown, the right policy course must be to act quickly and decisively: "It is not enough to argue that the science is uncertain. Given the risks, we have to be quite sure the science is wrong before following the sceptics. By the time we know it is not, it is likely to be too late to act effectively."[11] The IEA calculates that if we are to stick to the 445 ppm target the cost of each year of delay will be an extra $500 billion. This is because new capital investment, especially in electricity generation, has extremely high sunk costs, and the plants themselves have a long life – so every new coal-fired power station will emit carbon long into the future.[12] The safest option, therefore, is to act quickly and decisively to cut carbon emissions, but the uncertainty over potential costs dampens political will and makes binding international agreements difficult.

The second major – and related – variable is the *price* of investment in carbon mitigation. Future risks of investment in

9 M Weitzman, 'A review of the Stern Review of the Economics of Climate Change', Journal of Economic Literature, September 2007.
10 W Nordhaus, ' The Stern review on the economics of climate change', May 2007.
11 M Wolf, 'Why Copenhagen must be the end of the beginning', 1 December 2009.
12 IEA, 'World energy outlook', 2009.

low carbon technology are difficult to quantify. This is directly related to the uncertainties about the scale of the problem, and the government response. In particular, future regulations, taxes and subsidies for various technologies for mitigating climate change are unknown. This means that there is a risk that an investment may be rendered unproductive by new taxes or changed subsidies or increases in regulation. It is also because the rate of technological progress is unknown. If new low-carbon technologies can be invented and commercialised quickly, the costs will be lower than if they cannot.

Due to the various risks associated with low carbon investment and the scale of investment required, the UK government is proposing to create a GIB, along the lines of the European Investment Bank, Germany's Kreditanstalt für Wiederaufbau (KfW), or Spain's Instituto de Crédito Oficial (ICO). In June 2010 the Green Investment Bank Commission published a report which set out the challenges facing the UK's transition to a low carbon economy and proposed the establishment of the GIB to 'tackle the low carbon investment needs of the UK, working as a key part of overall Government policy'. This bank aimed 'to open up flows of investment by mitigating and better managing risk (rather than simply increasing rewards to investors)' and it was to do this by: addressing market failures which limited 'private investment in carbon reduction activities', rationalising government bodies and funds to provide 'coherence to public efforts to support innovation in relation to climate change' and 'advising on financing issues in central and local government policy making'. With a guiding principle that it should never crowd out the private sector, the GIB was to 'achieve emission reductions at least cost to taxpayers and energy consumers'. [13]

13 Green Investment Bank Commission, 'Unlocking investment to deliver Britain's low carbon future', June 2010; British Venture Capital Association, 'Considerations for creating a UK green investment bank', March 2010.

: 3 Investment requirements for a low carbon infrastructure

WHERE IS INVESTMENT REQUIRED?

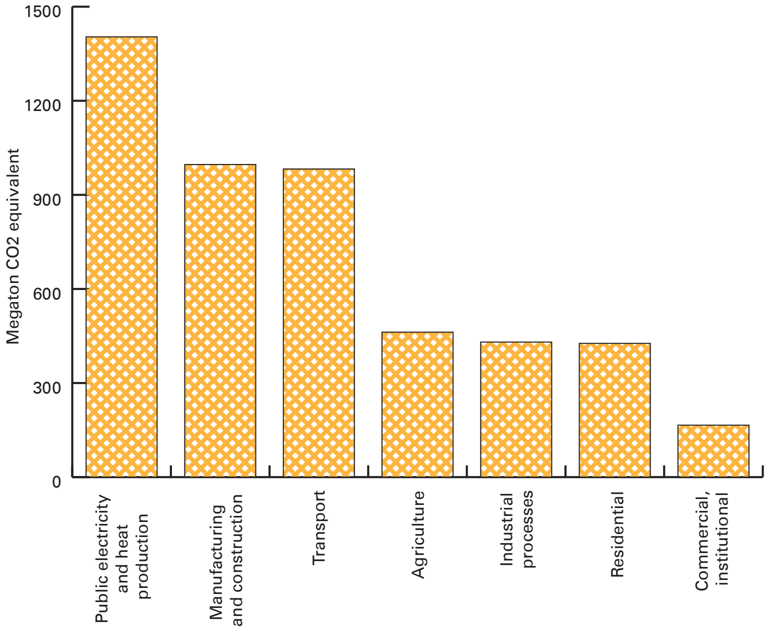
Chart 1 shows that the electricity and heat generation sector is by far the largest emitter of greenhouse gases. The sector therefore requires significant investment to facilitate the move to a low carbon economy. The sector generates 25.1 per cent of Europe's total greenhouse gas emissions. It is followed by manufacturing and construction, and transport, on 17.7 per cent and 17.5 per cent respectively. Not only is this the sector, therefore, where investment is critically important to tackle greenhouse gas emissions but it is also where some of the largest returns from building comparative advantage might come by investing in new energy and transport technologies that look promising but are not yet mature.

Recent studies have shown that early, strategic large-scale investment in R&D on technologies that have a high chance of gaining a short-term monopoly can be worthwhile, although it is of course highly risky.[14] It is no surprise that the world's three largest manufacturers of wind turbines are Denmark's Vestas, Germany's Enercon and Spain's Gamesa, the three countries in Europe with the longest history of wind power support.

However, these investments in emerging technologies are not necessarily the cheapest way to cut emissions. As Chart 2 shows, energy efficiency will provide the most carbon abatement at the least cost in the short term. This implies that the best strategy

14 R Inderst, 'Public policy, early-stage financing and firm growth in new industries', Bundesbank, December 2006.

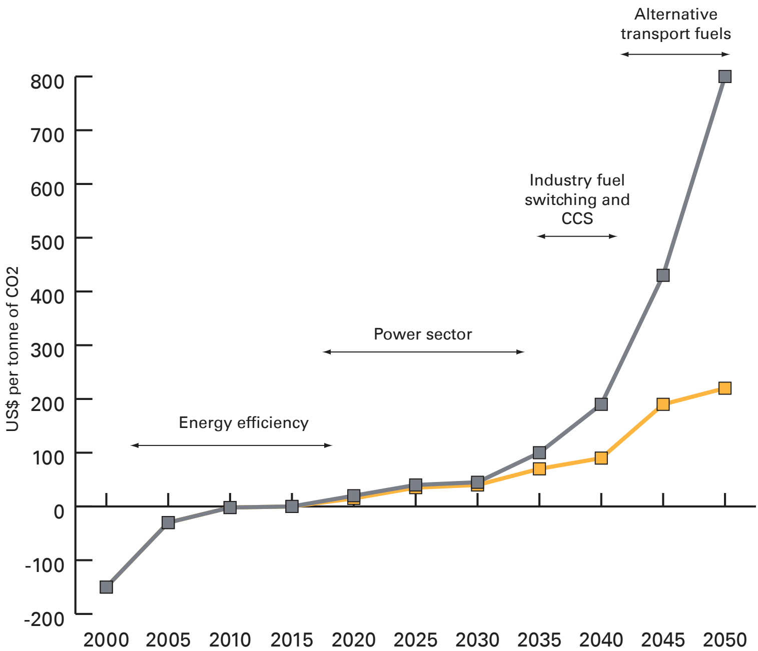
CHART 1. EMISSIONS BY INDUSTRIAL SECTOR



Source: European Energy Agency, Greenhouse gas emission trends and projections in Europe 2009, November 2009.

would be building new renewables and nuclear power in the period between approximately 2015 and 2035, then industry switching to low carbon fuel and carbon capture and storage (CCS) for electricity generation and heavy industry. Many efficiency measures will actually save money. Increasing the energy efficiency of cars and buildings, and installing district heat and combined heat and power systems all provide gains in the medium term, once the initial investment has been clawed back in cheaper fuel bills. This is because the technology is simple and mature, so firms do not have to spend large amounts on R&D. Policies which stimulate investment in emerging technologies should not be at the expense of investment in existing and cheap ways to cut emissions.

CHART 2. THE MARGINAL COSTS OF TRANSITION



Source: IEA, 'Energy technology perspectives', 2008.

Carbon abatement is likely to get more expensive over time. To minimise the costs of transition, and therefore the cost to economic growth, government policy has to ensure that the least-cost abatement mechanism is pursued at any one time. Energy efficiency measures are the low-hanging fruit: they are likely to save money in the long run, as they will cut the ongoing demand for traditional forms of energy. Energy efficiency costs less than new forms of electricity generation, CCS, and alternative transport fuels like hydrogen or battery power.

HOW MUCH INVESTMENT IS REQUIRED?

The European Commission projects that the cost of the renewables target, of 20 per cent of total EU energy consumption by 2020, will be €667 billion.[15] In the UK the Government in its December 2010 UK Government Green Paper on Electricity Market Reform estimates that around 30% of electricity in 2020 needs to come from renewable sources (largely onshore and offshore wind) up from 7% today in order to meet the legally binding EU target for renewable energy.[16] The OECD projects that OECD countries will have to invest $60 billion a year from 2015 on electricity generation, rising to nearly $90 billion by 2025. Rail will require between $30 and $40 billion a year between now and 2030.[17] According to Infrastructure UK, nearly £1 trillion of investment is required between now and 2030 to pay for all of the new infrastructure that the UK needs.[18] The December 2010 UK Government Green Paper on Energy Market Reform quotes OFGEM estimates that the UK needs by 2020 around £200 billion in generation, electricity networks and gas infrastructure of which at least £110 billion would be needed in new generation and transmission assets in electricity – over double the rate of the last decade. Fears of heightened competition for capital between countries in Europe, and within banks, venture capital and private equity funds themselves, has led many to call for a European-style national infrastructure bank to be set up in the UK. This would provide the gamut of financing for new green infrastructure, from grants, through venture capital funds that take early stage technology risk to commercial investments in specific projects, in both equity and debt forms and loan guarantees that take no technology or development risk.[19]

WHAT ARE THE SOURCES OF INVESTMENT?

Global investment in the green energy sector has risen quickly in the last decade, rising from $46 billion in 2004 to $173 billion in 2008. The crash had an impact, but not a devastating one:

15 European Commission, 'Economic analysis of reaching a 20% share of renewable energy sources in 2020', 2006.
16 Department of Energy and Climate Change, 'Electricity Market Reform', Consultation Document 7983, 2010.
17 OECD, 'Infrastructure to 2030: main findings and policy recommendations', 2007, Volume 2.
18 Infastructure UK, 'Strategy for national infrastructure', 2010.
19 Green Investment Bank Commission, 'Unlocking investment to deliver Britain's low carbon future', June 2010; British Venture Capital Association, 'Considerations for creating a UK green investment bank', March 2010; I Holmes and N Mabey: 'Accelerating the transition to a low carbon economy: the case for a green infrastructure bank', E3G, 2010.

green investment fell only to $162 billion in 2009, 7 per cent from the 2008 peak.[20] The evidence shows that the largest drop-off in financing has happened in the high-risk, high return venture capital sector, which is in the business of commercialising and marketing new green technology. Large energy corporates who were actually deploying mature green technology, on the other hand, had much less severe financing difficulties.

As Chart 3 shows, venture capital for green technology grew by more than 20 times between the first quarter of 2004 and the peak, in the third quarter of 2008, from $0.2 billion to $4.1 billion. Since then it has declined significantly, falling by 36 per cent. This is unsurprising, given the worldwide flight from risk during the financial crisis: venture capital funds take the largest amount of risk for the largest potential returns, so saw their funding drop off.

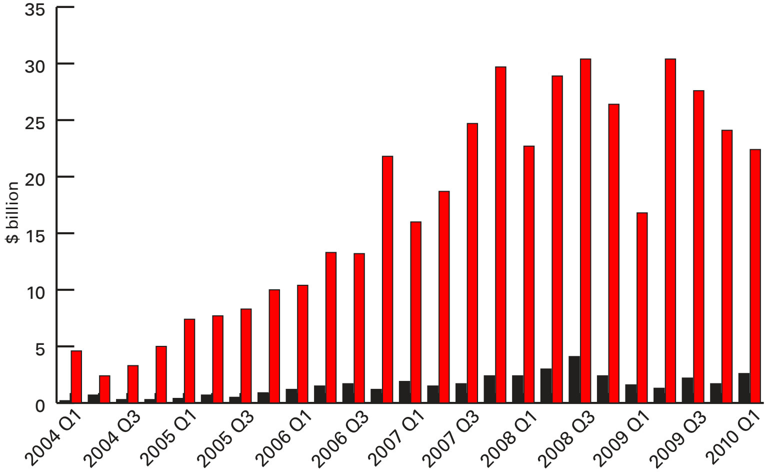
Table 1 shows in more detail what has been happening to sustainable energy investment since 2004.

Technology development, which represents the applied research that creates new technologies increased by only 30.6 per cent between 2004 and 2009. The biggest single increase came from government R&D packages as part of 2008-9 fiscal stimulus programmes. Corporate R&D remained constant throughout, but considering that project and commercialisation finance increased markedly it suggests that the global market signal for energy corporations was strongly in force from 2004.

Pre-financial crisis, the market signals wrought sharp increases in commercialisation and deployment of green energy technology. Equipment manufacturing and scale-up, where these technologies are made commercially viable and potentially profit-making, rose from a tiny $1.2 billion in 2004 to $28.3 billion in 2007, but because private equity and public markets crashed so badly in 2008, they fell back to $18.2 billion in 2009. Albeit from a low level, project finance for the construction of new projects, increased by nearly four times from $24 billion in 2004 to $119 billion in 2009, having reached a peak of $127.9 billion in 2008. This suggests that before the financial crisis at least, there was enough capital available to respond to the demand signals

20 New Energy Finance, 'Crossing the valley of death: solutions to the next generation clean energy project financing gap', June 2010.

CHART 3. FINANCE FOR GREEN INVESTMENT



Source: Bloomberg New Energy Finance.

TABLE 1. GLOBAL TRENDS IN SUSTAINABLE ENERGY INVESTMENT ($ BILLION)

	2004	2005	2006	2007	2008	2009	% change 2007-8	% change 2008-9	% change 2004-9
Technology development	20.9	21	23.1	26.5	28.5	27.3			30.6
Venture capital	1.2	1.4	2.2	3.9	4.3	2.7	10.3	-59.3	125.0
Corporate R&D	15.4	15	15.8	16.7	17.7	14.9	6.0	-18.8	-3.2
Gov R&D	4.3	4.6	5.1	5.9	6.5	9.7	10.2	33.0	125.6
Equipment manufacturing and scale-up	1.2	6	16.2	28.3	21.6	18.2			1416.7
Private equity	0.3	1	3.3	3.7	7.6	4.1	105.4	-85.4	1266.7
Public markets	0.9	5	12.9	24.6	14	14.1	-43.1	0.7	1466.7
Projects	24	45	71.2	108.2	127.9	119			395.8
Asset finance	15.8	33.4	58.7	89.2	108.4	100.9	21.5	-7.4	538.6
Small and residential projects	8.2	11.6	12.5	19	19.5	18.1	2.6	-7.7	120.7
Total new investment	46	72	109	157	174	162	10.8	-7.4	252.2

Source: Bloomberg New Energy Finance, ‘Global trends in sustainable energy finance’, 2010.

governments were putting in place. Asset finance for projects deploying commercially proven clean technology rose 6.6 times from the first quarter of 2004 and its peak in the fourth quarter of 2008. It has since fallen off by only 7.4 per cent: large companies that are rolling out clean energy infrastructure found it easier to secure financing than SMEs engaged in R&D intensive activity.

The markets responded quickly and efficiently to demand-side policies enacted by governments in the last decade, with total investment in sustainable energy increasing fourfold from 2004-9. But is it enough?

Climate Change Capital has estimated the infrastructure investment needs in the UK on energy efficiency, power generation, power networks, heat, waste, transport, research, development and deployment and international investments, totals £265.8 billion between 2010 and 2015; £294.6 billion between 2016 and 2020; and £186.7 billion between 2021 and 2025. This totals £747.1 billion, equivalent to £49 billion a year.[21] Infrastructure UK puts the figure lower, at £400-500 billion between 2010 and 2030, or £20-25 billion per annum. Taking these two as the highest and lowest points, this amounts to between 1.5 and 3.5 per cent of GDP per annum. But this includes *all* infrastructure investment, not just green investment. Much of the transport investment will be on roads. Gas, nuclear and coal fired power plants will continue to be built. Power network upgrades will include smart meters and more efficient distribution lines. This requirement of £20-50 billion investment per annum compares to the UK's entire spend on clean technology of around £6-7 billion in 2009.[22] But that was in the midst of a serious downturn, with a collapse in the EU ETS market and a falling oil price, and a mass flight from risk by investors and banks.

WHICH SECTORS ARE SUFFERING THE MOST FROM A LACK OF FINANCE FOR INVESTMENT?

Europe's energy market is dominated by very large players. Networks are natural monopolies, where economies of scale are

21 I Holmes and N Mabey: 'Accelerating the transition to a low carbon economy: the case for a green infrastructure bank', E3G, 2010.

22 Frontier Economics, 'Alternative policies for promoting low carbon innovation', July 2009.

so large that the barriers to market entry are very large. Power generation and distribution also have very large economies of scale, so tend naturally towards oligopoly.[23] Most countries in Europe have one distribution company, and between three and ten major generators who set prices.[24] The largest six power generators in the UK have total assets ranging from £6 to £15 billion. Even in recession their capital expenditures were significant. The owner of the UK's largest coal-fired power station, Drax, had a capital expenditure of £102 million in 2008 and £92 million in 2009. The National Grid's capital expenditure was £3.2 billion in 2008 and 2009.[25]

These large companies have direct access to debt capital markets through commercial paper or corporate bonds, are listed on stock exchanges and have easy access to bank lending. They had limited problems accessing finance throughout the credit crunch, when banks refused to lend, switching from bank financing to debt and equity from corporate bonds and equity markets.[26]

In contrast credit conditions were much harder for small and medium sized enterprises, like university spin-offs, parts manufacturers for energy efficiency technology and renewables, and start-ups that are attempting to prove the commercial viability of new technology. These companies, which have a turnover of less than £25 million, are highly leveraged – they have relied on bank financing to provide capital for their expansion and their revenues are more risky. Hence they are finding it difficult to get banks to renew loans as pre-crisis bank loans expire. They find very limited or no direct access to equity markets or the corporate bond market, because they are too small, so they do not have the assets to act as collateral against the risks they take. Banks have difficulty assessing the viability of loans to SMEs, and the volatility of the renewables and energy efficiency markets makes them high risk investments for banks and hence in terms of the risks involved more appropriate for equity than debt finance.

23 D Helm, 'European energy policy: meeting the security of supply and climate change challenges', EIB Papers, 2007.
24 See IEA, 'Energy policies of IEA countries – Germany', 2007, for a discussion of the benefits of European market liberalisation.
25 National Grid plc, 'NTS Regulatory Accounting Statements 2008-2009'.
26 UK Department of Business, Innovation and Skills, 'Financing a private sector recovery', July 2010.

Small and medium sized businesses have limited access to private equity markets because the cost of conducting due diligence on a prospective offering is not proportional to the size of the deal. This therefore excludes some small local energy renewables initatives, like district heating. This makes private equity investors favour much larger investments in firms that are offering mature products.[27] A business may have to be very large to get equity financing: most private sector funds will not provide equity to SMEs for capital projects that are worth less than £5 million. When they are conducting complex R&D, or seeking to conduct large capital expenditure, this can grow to £15 million.[28]

Many of these issues regarding the financing of small and medium size enterprises and early stage R&D are not peculiar to green technology businesses, and so may require more general policy action to tackle them. That is not the focus of this paper. This paper focuses on the case for policy intervention because of particular problems which are a characteristic of the energy market or of low carbon technologies which therefore require policy action.

For example, the particular corporate structure of the utility sector and the investment requirements may render the speed of response of the sector inadequate to meet the energy infrastructure requirements. This paper also focuses on the case for policy intervention where government, because of general market failures (eg in inadequate finance for R&D), wishes to intervene to promote a particular industrial sector, or sectors, for industrial policy reasons. This might be the case, for example, for R&D assistance to green technology businesses. It is important to keep these two reasons for policy intervention conceptually separate, as a confusion of them can lead to a lack of clarity in policy recommendations.

27 UK Department of Business, Innovation and Skills, 'Financing a private sector recovery', July 2010.

28 UK Department of Business, Innovation and Skills, 'The supply of equity finance to SMEs: revisiting the "equity gap"', September 2009.

4 Policies for promoting applied Research and Development

Private energy R&D in OECD countries fell from $8.5 billion at the end of the 1980s to around $4.5 billion in 2003.[29] Even public support for low-emissions energy R&D has declined by 50 per cent between 1980 and 2004.[30]

There are several reasons why optimal levels of R&D may not happen. Where new products are still 'immature', and are unable to compete on costs with market leaders, investment in R&D may be less than is optimal. Firms cannot always recoup all of the profits that arise from the research. Practically it is very difficult to do so: other companies use new technology and amend it enough to avoid breaking intellectual property law. Firms tend to under-invest in R&D when they cannot capture all of the intellectual property: it is often easier to copy others than to discover new technologies yourself. There are two uncertainties that investors in clean technology face – the uncertainty over the cost of emitting carbon, and the uncertainty over which low carbon technology will be the most profitable in the future. It may therefore be rational to wait before investing, to see if the carbon price really rises, or to wait until the market produces a cheaper technology – and then to buy it or copy it later.

Policies can be 'bent' towards alleviating the social cost (carbon dioxide emissions) and promoting the public good, which in this case is more and better R&D of applied green technology. The UK has one of the best scientific bases in the world, but has been only mediocre, especially compared to the United States,

29 OECD, 'Do we have the right R&D priorities and programmes to support energy technologies of the future', 2006.

30 IEA energy R&D statistics.

at converting that basic research into applied technology. R&D is in some ways a public good, which in economic jargon means less that it is 'good for the public' but that it is difficult to exclude others from using it.

R&D also has positive spillover effects: it creates clusters of expertise, with scientists, engineers and venture capitalists in close geographical proximity to each other, who share their ideas and technologies. In mature economies, economic growth is founded upon the increasing productivity of all of the factors of production – labour, technology and capital – which happens most quickly through technological change, when technology is deployed to make each of the inputs more efficient or more profitable. This relies on the creation and diffusion of knowledge, and interactions between industry and science are crucial.[31] Finally, R&D has enormous possibilities for cost reduction: it is estimated that every £1 spent on research on average leads to between £2 and £8 in cost reductions, compared to £1 spent on deploying new technologies.[32]

Thus government investment in R&D generally produces a social return greater than the private returns handed to the company it invests in. The energy economists Daniel Kammen and Robert Margolis estimate that the private returns from R&D are estimated at 20 to 30 per cent, while the estimated social rate of return is around 50 per cent.[33] Whilst this illustrates the divergence between social and private returns, even at this level of private return it would still be profitable to invest in R&D. A divergence between social and private returns does not necessarily justify government intervention.

Providing an R&D subsidy either through financial support or tax breaks has its costs. Inevitably, some innovations will fail to be commercial. Public sector investment may crowd out the private sector; identifying the line where government investment stops crowding in private investment and starts displacing it is notoriously difficult. When it starts to displace it, market signals

31 S Robin and T Schubert, 'Co-operation with public research institutions and success in innovation: evidence from France and Germany' Innovation systems and policy analysis, April 2010.

32 Frontier Economics, 'Alternative policies for promoting low carbon innovation', July 2009.

33 D Kammen and R Margolis, 'Evidence of under-investment in energy R&D in the United States and the impact of federal policy', Energy Policy, 1999.

are weakened, increasing the likelihood that investment will be wasted on projects that do not have the greatest marketability. Investment in deployment, especially, is linked to reduced costs for the technology, but the causation is not clear: cost reductions may *lead* to greater deployment, rather than the other way round. So forcing greater deployment may not lead to increased learning rates, especially if reduced costs would come predominantly through research, rather than 'learning by doing'.[34] Government should concentrate on longer term investment in technology that has not yet become mature.

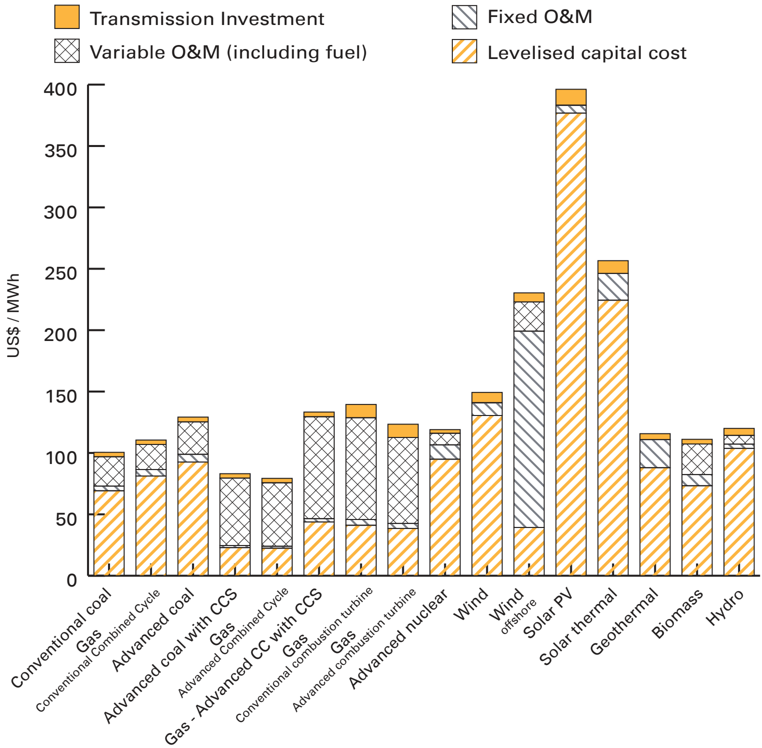
Much R&D is about reducing the costs of existing technology: refining it and making marginal improvements to it. Here, markets work effectively: in the market for wind turbines, for example, there are seven major manufacturers all competing with each other for market share and refining and improving their product in order to do so.

Some low-carbon technology is nearly 'mature', meaning that it is sold by several firms in a market and the demand for it is established. As Chart 4 shows, there are several technologies which are close to competing with coal, both with and without CCS, and with gas fitted with CCS. The chart shows the 'levelised' cost of an electricity technology, which shows the cost per megawatt hour (MWh) of a technology throughout its life, including construction, operation and maintenance and fuel costs. Some low-carbon technologies are close to being able to compete on costs with conventional coal, like nuclear, geothermal, biomass and hydro, and to a lesser extent, wind (though the costs of most renewable technologies varies according to location). They are still behind gas-fired stations, which are far cheaper to build, despite the high cost of the fuel.

However, the evidence shows that maturing renewables technologies' costs are falling quickly, by an average of 10 per cent across most sectors in 2009, even in wind, which is most mature. Solar photovoltaic cells using crystalline silicon technology are relatively expensive to manufacture, and are currently economic for large-scale generation only with subsidy and a sunny climate. The rate of technological progress has been reasonably quick, at around 10 per cent a year. But another

34 N Stern, 'Review of the economics of climate change', 2006.

CHART 4. 'LEVELISED' PROJECTED COSTS FOR ENERGY GENERATION, 2016



Source: US Energy Information Administration

solar cell technology, thin-film solar has made much faster progress. They are less efficient at energy conversion but are far cheaper to manufacture than crystalline solar, are a major breakthrough for large scale deployment, and their levelised capital cost may fall below combined cycle gas turbine plants in 2012 in the right conditions, according to Lazard, the investment bank.[35] However some argue that the relevant comparison is not between 'levelised' costs of different technologies but 'whole system costs' which include the additional costs which different technologies require in terms of 'back up' generation given the intermittent nature of the electricity that they generate . On such

35 Lazard, 'Levelised cost of energy analysis', June 2008.

comparisons some technologies such as wind power become even less cost competitive.

For technologies that have extremely limited markets, because they are still new inventions without a set of firms and a pool of financing to scale them up, or because they are projects that are very site-specific (tidal power, in particular, suffers from this problem) there may be less investment in R&D than might be optimal for society. Offshore wind is 2.5 times the cost of conventional coal, because of its extremely high fixed operation and maintenance costs – transmitting the electricity generated to the grid is expensive. Solar photovoltaic cells cost nearly four times as much as offshore wind, because the manufacture of the cells themselves is very expensive. Similarly, solar thermal, which uses solar panels to generate heat, is still too expensive to compete with gas-fired heating.

Rendering these technologies competitive with fossil fuels requires an intensive and expensive R&D effort, combined with market mechanisms that sift technologies that will never be able to compete from those that can.

The other potential market R&D failure is in the deployment and scale-up of new technology. This is down to uncertainty over the future profitability of one investment over another. There is always a chance that some hopeful looking technologies may never become 'mature', or capable of competing with fossil fuels, or that a new, related technology will render the older investment relatively unprofitable. This high degree of uncertainty discourages large upfront investment.

Because of these uncertainties, financial instruments and funds do not exist to cover the expense. Venture capital and government grants provide funds for early R&D, because they have high technology risk tolerance – their investment strategies entail hedging across many different technologies in the expectation that one will become commercially viable. They also want a return on their capital in a short-medium period. But building projects using new and unproven technology on a large, commercial scale is considered too risky by many banks or utility companies, who have plenty of capital to lend but are not positioned to back large-scale projects deploying new technologies. The total funds for commercially proven technology, like wind turbines or solar PV cells, are 10-15 times the size of those for unproven technology. This suggests government action may be justified to fill that gap, although this needs to be judged on a case by case basis.

Whether a government wishes to invest to fill that gap (almost inevitably involving at least some element of subsidy given the public good nature of the R&D) will depend partly on whether government wishes, for industrial policy reasons, to develop that particular sector, rather than to import the relevant technology from elsewhere. However, if a particular technology is particularly well suited to a particular country there may be good reason to provide support to develop that technology to meet the low carbon infrastructure needs of the country. Hence, in the case of the UK where offshore wind power generation and tidal power generation have some comparative advantage compared to other economies, there may be a case for support for R&D as part of the desire to see investment in low carbon infrastructure rather than simply for industrial policy reasons.

Frontier Economies highlighted a ‘valley of death’ for investment in green technology. This comes at the point where government support for R&D of new technology, and for its demonstration to business, falls off and the need arises to commercialise the technology by scaling it up and deploying it in a way that creates a return for business. Table 2 shows why this occurs. Venture capital funds are willing to take technology risk. Governments will provide R&D grants and trained scientists and engineers. But the commercialisation of new energy technologies, especially in energy generation is extremely expensive, and only banks have the kind of capital required. But they have very limited tolerance for technology and project development risk, as they do not have the knowledge to differentiate the potential productivity of one unproven investment from another. Thus ‘banks are always willing to back your second project’.

Closing the ‘valley of death’ can be done through two mechanisms: policies to stimulate the supply of investment, through increasing finance availability through agencies such as the green investment bank, and policies to stimulate the demand for investment, by cross-subsidy, regulating and taxing the energy generation, construction and transport industries themselves. In the following sections we examine appropriate

TABLE 2. THE RESEARCH, COMMERCIALISATION AND DEVELOPMENT LIFECYCLE FOR NEW TECHNOLOGY

Research and development	Demonstration	Deployment in a pilot	Diffusion and commercialisation	Commercial maturity
Develop technology concept and get intellectual property	Design and test prototype Build company	Prove technology in the field Market the technology	Prove that manufacturing process can be scaled – create a supply chain Prove technology generates a return at scale	Proven technology is sold and distributed
Government grants, university funding, venture capital	University spin-outs, venture capital	Some venture capital, private equity		Banks, corporate bond market, equities, supply chain finance
		The commercialisation valley of death		
Supply push policies			Demand pull policies	

Sources: New Energy Finance, 'Crossing the valley of death', June 2010; Frontier Economics, 'Alternative policies for promoting low carbon innovation', July 2009.

policies for deployment of green technology and then specifically policies for intervention on the demand and supply side.

: 5 Policies for deployment

As Table 2 shows, R&D occurs throughout the commercialisation of a technology – and after it has been adopted by a market, especially in energy efficiency. Creating better conductor materials in electricity transmission would reduce power loss. Improving internal combustion engine efficiency can be achieved by better onboard computers, and the use of bio-fuels mixed with conventional petrol and diesel. Plug-in hybrids, with petrol and battery power, are another potential source. But some R&D must be conducted at a basic level. We are still far away from a new source of transport technology (hydrogen is a long way off). CCS and offshore wind require a lot more R&D to make them commercially viable against fossil fuels.

A Cambridge economist, Tooraj Jamasb has quantified 'learning by doing' and 'learning by research' in energy technology. Table 3 shows the learning rates for various electricity generation technologies that are from renewable sources or have the potential to improve the efficiency of fossil fuel use. Much R&D happens on-site, as a new technology is marginally improved at each new plant. This is especially true for new conventional coal and lignite, for combined cycle gas, for waste to electricity plants and for new nuclear plants – mature technologies whose efficiency can be improved quickly and cheaply. On the other hand, renewables, especially those that are currently being scaled up to very large quantities, like onshore wind, combined heat and power plants, and waste to electricity see high rates of technical progress in both learning by research and learning by doing.

This suggests that policies on both the supply side of R&D and on the demand-side, to bring on the roll out of new (rather than mature) plants, may be justified, with a government

TABLE 3. LEARNING RATES FOR DIFFERENT ENERGY TECHNOLOGIES

	Capacity cost ($/kWh)	Cumulative R&D ($ millions)	Capacity (MW)	Learning by research (%)	Learning by doing (%)
Pulverised fuel supercritical	1493	7461	19034	6.0	3.8
Coal conventional	1308	35452	650512	1.3	12.4
Lignite conventional	1275	7877	105120	1.7	5.7
Combined cycle gas	509	25448	62301	2.4	2.2
Large hydro	3426	17881	452556	2.6	2.0
Combined heat and power	920	14913	31084	8.9	0.2
Small hydro	2431	1171	23708	20.6	0.5
Waste to electricity	3528	18928	11338	43.7	41.5
Nuclear light water reactor	3090	97211	328391	26.7	36.3
Onshore wind	2094	7099	2913	26.8	13.1
Solar thermal power	4990	4498	256	5.3	2.2
Offshore wind	2066	261	82	4.9	1.0

Source: T Jamasb, 'Technical change theory and learning curves: patterns of progress in energy technologies', Cambridge Working Papers in Economics, 2006.

subsidy especially on the R&D of technologies that are close to commercialisation. Jamasb found that the highest learning rates are in close-to-market technologies, while very immature technologies, like solar thermal power and offshore wind have slow rates of technical progress. A GIB that provided finance for investment based on return to the taxpayer would not necessarily promote R&D in close-to-market technologies, but in the roll-out of marketable ones. This might not lead to the largest reduction in costs, compared to a government fund that subsidised R&D on the supply side of investment, and used ‘demand-pull’ policies to provide market signals, and subsidy by energy users themselves, rather than the taxpayer, for the commercialisation of green technology.

The precedents from other European companies show that an R&D policy, heavy on commercialisation, which tries to divert resources to start-ups and small and medium-sized enterprises, is the most effective. The European Investment Bank provides energy infrastructure funding for large-scale projects of more than €25 million, but only if they are undertaken by both public and private sector borrowers. It provides funding for smaller investments, up to €25 million, for SMEs with fewer than 250 employees, and for energy technology and efficiency R&D, the EIB will provide up to 75 per cent of the project cost.[36] France’s OSEO was set up in 2005 to supply funds and advice to SMEs. It provides a combination of grants and zero-interest advances to SMEs and larger enterprises for R&D, innovation and deployment activities. It spends the majority of the funds on deployment of new technology. Since 2008, OSEO has been offering €300 million of grants to support collaborative projects between research centres and enterprises, and the projects must be headed by a large corporation capable of rolling out the technology. The allocations for green investments have actually only been a small proportion of OSEO’s budget. Similarly, Spain’s ICO state development bank has spent only a small proportion of its budget on renewable energy since 2000: on average, 0.88 per cent of its total budget.[37]

Investment in clean technology equity funds has a much higher risk – return profile than investment in bonds. Clean energy funds, which offer the types of equity investment that a GIB would be competing against in terms of equity investment, had an average twelve-month return of 29.2 per cent in 2009.[38] In 2008, after the collapse of the equity market, clean energy equities listed by the WilderHill New Energy Global Innovation Index fell by 61 per cent, before rising 39.7 per cent in 2009.

36 European Commission, ‘FP7 funding sources: energy research’, at ec.europa.eu/research/energy/eu/funding/other/index_en.htm
37 ICO, ‘Annual report 2009’.
38 Bloomberg New Energy Finance, ‘Clean Energy League Tables’, March 2010.

The New Energy Finance index fell peak-to-trough by 71.8 per cent over the crisis, before rebounding by 88 per cent.[39] This compares to a peak-to-trough fall of 48 per cent for the FTSE 100 index and 57.7 per cent for the wider S&P 500 index. The FTSE has since bounced back by 50.1 per cent, and the S&P by 60.1 per cent.[40] This high volatility return profile has tended to deter investment, and is likely to continue to do so unless government takes on a proportion of the risk, which could act to crowd out private investors. Hence there are good reasons to consider that the social return to early stage investment in clean technology exceeds the private return and hence that in some cases there may be a case for government intervention either through grants or equity investment. However it must be recognised that this will lead to a lower return than would be expected by a fully commercial bank or fund investing in these areas.

39 Bloomberg New Energy Finance, 'Clean Energy League Tables', March 2010.
40 Financial Times, Thomson Datastream data.

: 6 Demand side policy intervention

Many deployment policies happen on the demand side for investment, passing on the costs to the consumer of energy. The presence of a carbon price helps stimulate the deployment of renewables and lower carbon alternatives, like natural gas. Feed in tariffs, carbon taxes and renewables obligations also increase the price of carbon-intensive energy relative to low-carbon energy, or subsidise the latter. Other examples include: reduced taxes for bio-fuels in the UK and US; tenders for tranches of output, as with the now defunct 'non fossil fuel obligation' in the UK; subsidy of the infrastructure costs of connecting new technologies to networks; procurement policies of public monopolies, with soft loans by governments, regulatory agreements to allow the recovery of costs, and with nuclear waste, government assumption of liabilities; procurement policies of national and local governments, which include demonstrator projects on public buildings, use of fuel cells and solar technology by defence and aerospace; hydrogen fuel cell buses and taxis in cities; and energy efficiency in buildings.

Unless the opportunity cost of investment in new technology is lower than the cost of fossil fuel investment, firms will not invest. The lack of a carbon price, which effectively forces up the cost of conventional technology, means that almost inevitably low carbon technology will not be invested in without government intervention. The other causes of market failure in investment in R&D and commercialisation of new technology are subsidiary to those, more basic market failures. The lack of access to capital can be a problem (and this is considered further in the following section), even if the market signal is loud and clear, but firms and households that pollute will only demand finance for investment once the market signal exists; and that demand will filter through into basic and applied research. Commercialisation of research will only happen if corporations that are capable of large-scale projects are incentivised to pay for it. An increased cost of the status quo elicits greater interest in the range and cost of substitutes that are available on the market. Thus, the main requirement for increasing innovation in green technology is a strong market signal.[41]

Where possible, this signal should be market based. Pro-market carbon abatement mechanisms work more effectively at promoting growth than old-fashioned regulation where governments impose restrictive regulation on greenhouse gas emissions at the individual firm level. It imposes a larger drag on growth than a system that allows the costs of carbon abatement to be borne by those firms most able to take them: if individual firm quantities of pollution are regulated across the board, overall output will be lower, and unemployment higher.

This is why governments have tended to use taxes, subsidies and cap-and-trade mechanisms where possible. This is to create a price for emitting. They have the advantage of allowing firms and households to adjust their behaviour to a price signal, rather than being forced to reduce their carbon emissions by a strict amount set by central government. This corrects markets, in that it makes firms with more modern, lower carbon plants more competitive, but it allows firms with more old fossil fuel plants to adjust to prices rather than imposing an immediate investment of a potentially unaffordable size. But cap and trade, tax and subsidy policies have to deal with the multiple uncertainties discussed above. This makes reducing the cap on the quantity of emissions at the right pace, or raising the tax and subsidy regime to create an emissions price, very difficult.[42] The government cannot know exactly what price is required to cut the desired amount of carbon emissions each year, to maximise the investment in carbon technology at the least cost. If the government increases taxes too much, it risks driving many firms out of business, sharply curtailing the sector's carbon emissions but at the expense of an excessive fall in output. If they subsidise a particular low carbon technology too much, they can create investment booms, and hand large windfall gains to the producers of the technology.

41 Frontier Economics, 'Alternative policies for promoting low carbon innovation', July 2009.

42 M Weitzman, 'Prices vs. quantities', Review of Economic Studies, 1974.

The most efficient demand side policies – and therefore the most pro-growth policies - influence the market at the most macro level possible, in an attempt to influence the prices and quantities of carbon emissions rather than the prices and quantities of particular types of carbon abatement. This is because it caps the bad – the carbon emissions – but leaves firms to decide what technology should be employed where and at what cost.

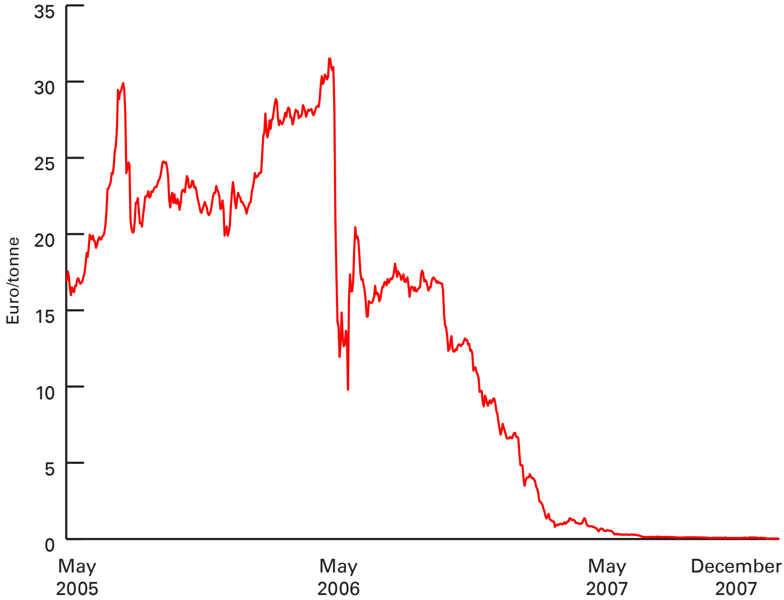
Quantity support, like tenders for tranches of output, and pro-new technology procurement policy, may not provide sufficient incentives for suppliers to try to reduce costs. The supplier may also not be able to pass an excessive cost burden on to the consumer, because the government may not set the quantity high enough to increase prices to a profitable level. When supporting prices, government may set them too low, in which case no new deployment would happen, but if it is too high the government merely hands large financial rewards to suppliers, which are essentially government created rents. With traded quantity instruments, like ROCs, the market is left to determine the price, with firms trading quotas for cash. This leads to price uncertainty; if the quantity demanded is too high, supply constraints may lead to high costs. If the quantity is too low, suppliers may not be able to scale up their operations enough to reduce costs.[43]

The UK has failed to create a market signal over the last decade strong enough to facilitate the roll-out of green technology, especially in electricity generation and in buildings efficiency, where some of the cheaper reductions in CO2 emissions can be made.

This is partly because the EU's Emissions Trading Scheme has failed to create such a signal. In the initial phase of the system, between 2005 and 2007, governments handed out far too many allowances. This meant that very few firms had to buy any to cover their emissions at the end of the period. After peaking at €30 a tonne in May 2006, the price collapsed to €0 by the end of the phase (See chart 5). This compares to the Stern Review's central case estimate that the carbon price should be $314 per tonne, though many other studies have made rather lower estimates at closer to $50 per tonne.

43 N Stern, 'Review of the economics of climate change', 2006.

CHART 5. EU ETS PHASE 1



Source: European Climate Exchange.

In the second phase the European Commission demanded a 7 per cent cut in emissions from 2005 levels from governments. It sent back National Allocation Plans that were too generous for member states to tighten. The price rose to nearly €35 a tonne in mid-2008, but the credit crunch and subsequent recession depleted economic activity to such an extent that the price again fell, bottoming out at €10 in early 2009 and hovering around €15 thereafter (See chart 6).

The creation of a price for such a large market is difficult, and the quantity of carbon abated is subject to a variety of factors that are external to the system: the price of fossil fuels (if they fall, the carbon price falls); the rate of economic growth; the prices of low-carbon substitutes (if they fall, they would cause the carbon price to fall too, as firms left the ETS market). With macroeconomic scope comes greater uncertainty and volatility, all of which dampen investment incentives.

CHART 6. EU ETS PHASE II

Source: European Climate Exchange.

Most economists argue that €15 a tonne is far too low to stimulate the required investment. The UK's largest emitter of carbon dioxide, Drax, suggested in February that it needed to rise to €30-40.[44] Researchers at Harvard University argue it should be over €100 to stimulate the burst of investment needed in the next 10 years.[45] Happily, from 2012 the EU is changing the rules to make the ETS more effective, and it will almost certainly create a higher price for carbon. The cap will be lowered annually by 1.74 per cent, bringing it down to 21 per cent below the level verified emissions by 2020, to meet the EU's 20 per cent cut in emissions target. By 2013 50 per cent of the allowances will be auctioned at the beginning of the phase, so that firms will have to pay governments for them. The UK's auctioning of allowances should bring in around £40 billion between 2013 and 2020.[46] By 2027, they hope this will rise to 100 per cent. In 2012,

44 Financial Times, 'Drax chief says carbon prices too low', February 2010.
45 D Acemoglu et al, 'The environment and directed technical change', National Bureau of Economic Research, April 2008.
46 Committee on Climate Change, 'Building a low-carbon economy – the UK's contribution to tackling climate change', 2008.

air travel will be included, as will aluminium producers and the CCS industry in 2013.[47] All of these reforms should ensure a higher and more stable future price for carbon, which creates incentives for future investment.

COMPARING QUANTITY AND PRICE-BASED SUPPORT: FEED IN TARIFFS AND RENEWABLES OBLIGATION

Those countries that have been most successful at improving carbon emissions have acted over and above the ETS to create certain and higher prices for low carbon technology than high carbon technology. Those that have done so over a long term have been particularly successful.

In Europe, two main types of policies have been used. The renewables obligation certificate has been used in Belgium, the United Kingdom, and Italy, while the feed in tariff has been used in France, Denmark and Germany and more latterly for small scale generation in the UK (and is being proposed to be used more widely in the UK in the proposed energy market reforms).

Feed in tariffs have been most successful where they have created price certainty, and where markets have been used to choose the low-carbon technology deployed, rather than government. Markets and profit-orientated decisions based on a careful assessment of cost and risk are more likely to discover commercial successes.[48] Governments may still choose specific policies to promote particular technologies, especially those that could benefit from deployment and commercialisation support, or which have particular strategic importance. This can be done through technology specific quotas, or increased levels of price support for certain technologies. However, this has the disadvantage that it could lead government to choose to promote uneconomic technologies. Immature technologies which have a longer process of learning to go could receive greater support; undifferentiated support will merely help those technologies which have already been established. Yet such support might be more appropriately promoted on the supply rather than the

47 L Parker, 'Climate change and the EU emissions trading scheme (ETS): looking to 2020', Congressional Research Service, January 2010.

48 N Stern, 'Review of the economics of climate change', 2006.

demand side, through grants and equity investment in R&D. In the USA, for example, onshore wind accounts for 92 per cent of new capacity in green power markets.[49]

Sweden has imposed a carbon tax since the 1990s, to make polluters pay for their emissions. Germany, Denmark and Spain have used feed in tariffs for renewable energy for several years. They provide a guaranteed higher price for renewable energy to overcome the higher cost of installing renewable energy generation compared to gas, coal, nuclear and oil.

Those governments that have been most successful at increasing the uptake of renewables have used wide-ranging feed in tariffs. These subsidise electricity generation from renewables. Private individuals pay for the subsidy through their energy bills, rather than through taxes; energy suppliers must buy renewable electricity from generators, for which they pay regulated prices.

This system has been very successful, but costly at first sight. Germany has been running a feed in tariff since 1991. It has installed 12.5 per cent of its electricity from renewables sources by 2010, and passed its EU target to have 4.2 per cent of total primary energy supply coming from renewables from 2006. The market share of renewables has grown at an annual average rate of 9 per cent since 1995, rising from 4.9 per cent to 10.1 per cent.[50] Solar in particular has seen remarkable growth: Germany had installed 3800 MW by 2008, compared to 0.4 MW in the UK.[51] Germany has the third largest supply of wind power in the world.[52]

The difficulty with the system comes in the government deciding on the schedule of tariffs. The schedule is based on equalisation of cost across all technologies, so that a company should theoretically make the same profit whichever technology they use. Biomass has the lowest tariff, as it is the least expensive technology, at 3.78 eurocents per kWh. Solar photo-voltaics, at the other end of the scale, are given 56.8 eurocents per kWh. These prices are guaranteed for 20 years, with an annual rate of price reduction between 1 and 5 per cent, depending on

49 N Stern, 'Review of the economics of climate change', 2006.
50 International Energy Agency, 'Energy policies of IEA countries – Germany', 2007.
51 Frontier Economics, 'Alternative policies for promoting low carbon innovation', July 2009.
52 International Energy Agency, 'Energy policies of IEA countries – Germany', 2007.

the technology, to account for falling costs as technologies are improved, to provide certainty on the part of the investor that subsidy will not be removed and the investment rendered unproductive.[53] This system has been expensive but highly successful in promoting the adoption of new technologies.

The IEA estimates that it will have cost €68 billion from its inception in 2000 to 2012, when the first subsidies are due to expire. Subsidies to the solar industry have been very high in relation to their output – 20 per cent of the total feed in tariff budget has been handed to the solar industry, although it contributes less than 5 per cent of the resulting generation.[54] The schedule of tariffs has been highly successful in increasing the market share of renewables, but has failed to allocate resources to the least-cost low carbon technology. Solar has taken a disproportionate share. The government aims to have the tariffs that most accurately reflect market conditions, but the process relies on estimates of prices.

There has been greater investment in renewables than under the UK's renewable obligation scheme. This is because renewables are already prone to considerable price uncertainties, and the uncertainty over the value of a renewable obligation certificate amplifies the uncertainty – which discourages investment.[55]

A product of the tariff system has been a solar PV industry, which subsidises the sector directly through the feed in tariff schedule. This has been effective, creating many jobs in the solar PV industry in Germany. But this is not without its risks: government-stimulated investment in particular technologies always risks an investment boom that is potentially unproductive. The high tariff for solar energy has been created to increase technological advancement and create a solar PV industry in Germany.

The advantages of a feed in tariff has been the investor security that it guarantees. The disadvantage is that the price for renewables is worked out by committee rather than through market mechanisms, and the degree of subsidy comes down very slowly, so there is less incentive to conduct further R&D to improve the technology and increase learning rates.

53 International Energy Agency, 'Energy policies of IEA countries – Germany', 2007.
54 International Energy Agency, 'Energy policies of IEA countries – Germany', 2007.
55 N Stern, 'Review of the economics of climate change', 2006.

The IEA estimates that between 44 per cent and 53 per cent of the increased payments to renewables generators have been in excess of the cost of provision – this represents a large surplus handed to producers. The IEA notes that energy efficiency measures would be far cheaper, with even the most expensive building retrofits costing only €20-30 per tonne of CO2, compared to €1000 per tonne of solar.

Sweden, on the other hand, has relied upon a carbon tax and a renewables obligation scheme to drive up investment in clean energy technology. This has wrought impressive results: by 2006, 47 per cent of electricity was generated from renewable sources.

The renewables certificate system has been in force since 2003. All electricity generators receive a certificate for every MWh of renewable energy they generate with solar, wind, small hydro, bio-energy and peat CHP plants. The system was designed to increase the use of renewable electricity by 17 TWh from 2002 and 2016, equivalent to 0.8 TWh per year. Between 2002 and 2005 renewable electricity production increased by 5 TWh, or 1.6 TWh per year. Electricity suppliers must then obtain electricity that equates to a regulator-set percentage of the total electricity of supply, passing on the costs to their consumers. The size of this percentage grows year on year, increasing the demand for renewable electricity and certificates. To provide long term certainty for investors, the policy will continue to 2030. And to prevent long-term subsidies to older renewables plants, they are allowed to earn certificates for 15 years only, and in 2014 any plant built before 2003 will lose their ability to earn certificates.[56]

The system is generally held to be cheaper than a German-style feed in tariff system. In 2005 customer payments were equivalent to an average rate of nearly 10 eurocents per kWh, with estimates suggesting that by 2012 this will reach a rate of 10.5 eurocents per kWh. [57] The Swedish system, on the other hand, imposed average costs of 0.03 and 0.04 euro cents per kWh between 2003 and 2006.[58]

56 IEA, 'Energy policies of IEA countries – Sweden', 2008.
57 IEA, 'Energy policies of IEA countries – Germany, 2007.
58 IEA, Energy policies of IEA countries – Sweden', 2008.

However, it is likely that the feed in tariff is more successful at promoting investment in new plant which given the legally binding EU target for renewable energy by 2020 is necessary, even though it may be less cost effective than a system of renewable obligation certificates. The feed in tariff regulates the *price* the energy generator receives for the renewable electricity it produces. This reduces the price risk the investor faces. The investor in new renewables generation is guaranteed a stable price for the duration of the tariff system, reducing uncertainty. In a relatively liberalised market, such as the UK, this price stability is especially valuable, because market prices can fluctuate widely, forcing companies to take out hedging contracts to reduce their price risk. The price stability offered by a feed in tariff eliminates that hedging cost.

The renewable obligation certificate system guarantees the *quantity* of renewables electricity that the energy supplier must buy. The price of the traded certificates depends on the quantity required, and varies widely – it suffers from the same problem as the ETS, in that prices vary according to the volume of renewables the regulator demands, rather than the volume of renewables depending on the price the regulator sets. Thus the price risk for an investor in a new renewables plant is high under a certificate system.

As noted above, when adjudged by total costs, the German feed in tariff has been expensive. But the amount of renewable energy delivered by the German system has been far higher, making it much more expensive in total but only marginally so if one measures costs per kWh.[59]

Because feed in tariffs guarantee prices for long periods, they create legally guaranteed revenue streams for investors. These help to overcome the very large price uncertainties that are inherent in new technologies. And as the Stern Review team put it, 'the price uncertainty of tradable deployment support mechanisms amplifies this uncertainty'. [60]

59 L Butler and K Neuhoff, 'Comparison of feed in tariff, quota and auction mechanisms to support wind power development', Cambridge Working Papers in Economics, 2005.

60 N Stern, 'Review of the economics of climate change', 2006.

: 7 Supply side measures: the case for the Green Investment Bank

The previous section considered the demand side measures which can be taken to promote investment in a low carbon infrastructure by ensuring that there are the right price signals to encourage investment. However, there is still the need to ensure that there is the supply of finance necessary for the amount of investment required. Given that the scale of investment in renewable energy is required at much higher rates than in the past, as was highlighted in Section 3, concerns have been raised that even if the price signals are right there may still be insufficient investment because of market failures in the supply of finance for investment.

For example, the UK Green Investment Bank Commission which reported in June 2010, identified a number of market failures and investment barriers in financing low carbon infrastructure. The first barrier identified was the existence of market investment capacity limits and limited utility balance sheets capacity. The second was political and regulatory risks stemming from the fact that government policy determines expected returns and this has been exacerbated by the number of numerous policy changes. Thirdly, there are confidence gaps among investors due to technology risks, a lack of transparency in government policy and high capital requirements for commercialisation.[61] The Commission therefore proposed that a GIB should be established with a very wide remit to promote a low carbon energy infrastructure. It was suggested that this remit should include: advising on financial issues in central and local government policy making; providing early stage growth, equity

61 Green Investment Bank Commission, 'Unlocking investment to deliver Britain's low carbon future', June 2010.

and investment; providing green bonds; providing insurance products; long term carbon price underwriting; and the purchase of completed renewable assets.[62]

Those that advocate a wide-ranging GIB, which will help to alleviate the whole gamut of large and systemic market failures, tend to assume that the majority of problems can be solved by creating a set of clever investors to direct a large portfolio of funds to increase the supply of cash, bonds, and equity financing towards investment in low carbon technology. Therefore they suggest that the bank could underwrite a minimum carbon price to rebalance investment risk towards high carbon technology (although this is a demand side measure which seems to be straying outside what would normally be regarded as the role of a bank). The bank, it has also been suggested, could reduce the heightened risk caused by policy and regulatory uncertainty. Investors are always nervous about large and long-term investments in green technology in case governments change subsidy or price support regimes, thereby reducing the taxpayers' costs. By co-investing it is hoped that governments will have less incentive to expropriate investments in this way.

Of course, there are alternative ways of achieving the same policy ends, many of which would be more effective, and do not involve co-investment. The government could impose a carbon floor price by a carbon tax on the industries involved in the EU's Emissions Trading Scheme, with the proceeds flowing through to the finance ministry, as the UK Government are now proposing. Government could sign contracts with energy companies promising to compensate for any changes in subsidy or other regime which adversely affects profitability. In addition the UK Government could for example provide similar guarantees or contractual assurances to those enacted in France and Germany, where government has stated that it will not change legislation giving incentives to encourage renewable energy generation for qualified projects, and/or, less onerous, commit to certain levels of renewables, energy efficiency measures, over long time frames.

More considered analysis of the case for the GIB focuses solely on the supply side of the investment market and identifies three

62 Green Investment Bank Commission, 'Unlocking investment to deliver Britain's low carbon future', June 2010.

key areas where a GIB may have a role to play: the provision of equity to early stage commercialisation of new technology; provision of insurance/loan guarantees to remove some of the project development/construction risk associated with large projects eg offshore wind and nuclear power projects; and the facilitation of long-dated debt through such mechanisms as purchase and securitisation (through green bonds) of project finance loans.[63] The case for provision of equity to early stage commercialisation of new technology was considered in Section 4, so in this section we focus more particularly on the other two areas where GIB may have a role to play. However, before doing so we look more specifically at some of the infrastructure specific market failures.

INFRASTRUCTURE-SPECIFIC MARKET FAILURES

One of the areas where it is felt that there is market failure is the supply of debt to large energy infrastructure projects. Since the financial crisis it has become more difficult to obtain long dated debt finance. Banks are generally unwilling to provide project finance loans for longer than ten to fifteen years (at most) compared to project finance loans, before the crisis, of 20 years or more. The investments and hence the financing requirements tend to be very large, often more than €1 billion – too large for a single institution, even banks.

Before the financial crisis, the loan syndication market allowed banks to team up to finance investments that are so large that they would not be able to supply all of the finance on their own. Since the crisis, they have stopped being involved in these types of investments, which are large, risky and over very long periods. They are difficult to marry up to their liabilities, which are short term and liable to business cycle fluctuations. In addition, due to the breakdown in trust between banks, the loan syndication market has broken down such that project finance bank financed deals of greater than £50-100m are much harder to execute as they now rely on clubs of banks negotiating the deal. New and necessary regulation to impose higher capital requirements on banks are also limiting their risk taking. Banks are not necessarily the best vehicles for cycling saving to infrastructure investment,

63 Ernst & Young LLP, 'Capitalising the Green Investment Bank: key issues and next steps', October 2010.

because the maturities of their liabilities are so different; 10-25 year bank investments in project deals are now much diminished, and are likely to remain so in the future.

What many see as the financial holy grail is marrying up institutional investors and infrastructure projects. Institutional investors – pension and insurance funds – hold large resources and are willing to invest over long periods. If pension funds and insurance companies buy enough green bonds to cover all of the UK's investment needs (£265 million) over the next five years, it would only take up 5 per cent of their annual bond investment. By 2015 this would amount to almost 9 per cent of their total assets.[64] However, institutional investors seek relatively safe assets, with returns about 2 or 3 per cent above the consumer price index; typically, around 5 per cent a year. They need to ensure that their liabilities and assets are closely matched, and since the crisis of 2008 they have been moving away from risky equity markets.[65] As other investors have fled risk since the financial crisis, the increased demand for their preferred classes of investments (AAA to AA-) has driven down yields, making it more difficult for them to meet their annuities and liabilities. The majority of infrastructure securities are rated BBB- by credit rating agencies, while institutional investors would only ever go as far as BBB+ as an absolute minimum and more generally A or A-.

Prior to the financial crisis monoline insurers such as MBIA and Ambac used to provide insurance for corporate and project bonds, guaranteeing the monthly revenue for the purchaser of the bond. They also supplied the expertise in the sector to assess and monitor the project risks involved. However most of the monocline insurers succumbed to the credit crisis: their capital requirements were lower than banks, and so they were able to take more risks during the boom. Now financial market conditions and to a degree regulators are frustrating their re-emergence.

Hence proponents of the GIB therefore suggest the bank should purchase and securitise project finance loans, which can be financed through the sale of green bonds so as to increase

64 Green Investment Bank Commission, 'Unlocking investment to deliver Britain's low carbon future', June 2010.
65 Lane Clark and Peacock LLP, 'Accounting for pensions 2010', August 2010.

market capacity. Insurance companies and pension funds would be willing to buy bonds from the GIB because of the implicit or explicit sovereign guarantee. However, it may take several years to build up the expertise that is required. If it had a purely commercial objective to make money wrapping and securitising infrastructure debt, there is no reason why a market could not do it more efficiently. If it had a public interest remit, supplying loan guarantees to projects which are uneconomic under normal market conditions, backed by the taxpayer, rather than insurance based on market-priced assets and liabilities, then it could not be off the government's balance sheet. In the UK, the National Audit Office's rules mean that government activities that create liabilities to the taxpayer must go on the government's balance sheet.

However, there is evidence that market intermediaries are stepping in to marry up supply and demand for commercial projects. Hadrian's Wall Capital in London is teaming up with the insurer Aviva, to create a £1 billion vehicle to slice up and securitise infrastructure debt into senior and subordinated debt, sending the better quality debt to institutional investors and the higher risk debt – mostly the debt connected to the higher risk areas of the project, like construction – to investors who are most willing to take it.[66] The product is structured in such a way that the rating of the project bonds can be improved from BBB- to at least BBB+ which would make them attractive to institutional investors. This would be done through the introduction of a layer of subordinated debt into the project debt.

The product integrates financing with a package of services, notably:

- Cash subordination to align interests;
- Initial debt structuring and negotiation;
- Ongoing surveillance, monitoring and reporting;
- Acting as managing creditor on behalf of senior debt.

In essence the product fulfils many of the services that were formally provided by monoline insurers, which indicates that this particular role of the GIB may well be nugatory – particularly by the time it is established.

66 Allbusiness.com, 'Aviva in strategic partnership for a new debt vehicle', Tuesday, 23 February 2010.

This illustrates a wider point regarding any proposal for government intervention in the financial markets of a similar type to the GIB. In order to justify intervention it is important to be clear that the market imperfection or market failure is long term or permanent. Otherwise government intervention risks preventing the emergence of a market solution to the problem. In this case a market imperfection, arguably caused by the particular circumstances of the financial crisis and the resultant financial difficulties of the monoline insurers, looks as though it may be 'ironed out' before there has been a public sector response – rendering the public sector intervention unnecessary. For there are several potential disadvantages of such government intervention which are considered below.

THE POTENTIAL COSTS OF GOVERNMENT INTERVENTION

There are three potential disadvantages of government intervention such as that proposed through the GIB. The first is lack of fairness. It could be argued that by supplying taxpayer money to capitalise the bank, and to guarantee loans for green investments, governments are substituting taxpayer funding for placing the full cost of the carbon emission on the polluter – redistributing money from the taxpayer to the polluter. If the costs of polluting are not internalised, the incentive to change behaviour is weakened. The taxpayer would be subsidising investments in low-carbon technology. This may mean that energy bills would increase less than if the energy *consumer*, rather than the taxpayer, paid for the investment. The true cost of emitting carbon dioxide by the energy generator and the end consumer would not be revealed, as the government would be taking on a portion of the investment risk in clean generation.

The European Union has sensible rules about state aid: it grants aid of this type only if the 'polluter pays' principle is adhered to; if the government investment has an incentive effect, changing the behaviour of the polluter; and if the same behaviour could not be achieved without the aid, through taxes and regulations.[67]

Second, state aid of this type is often subject to capture by special interests. The bank may be tempted to stray from its

67 European Commission, 'State aid policy and energy policy for Europe', April 2008.

remit to invest in the infrastructure most likely to reduce carbon emissions, and to invest in economic growth and jobs as well. In fact, it would be difficult for the bank to invest efficiently: many manufacturers that are most likely to provide wind turbines, power cables, smart meters, home energy efficiency retrofitting, or technology to improve car engine efficiency may be based abroad – especially Denmark, Germany, the US and China – and it might be difficult for a bank seeded with UK taxpayer capital to invest overseas. It may end up picking sub-optimal investments based in the UK that would end up being uneconomic. It could also be subject to political interference. Unless its remit was broadly defined to find the most productive investments to reduce carbon emissions, it would end up picking winners in favoured sectors (wind or solar) over politically controversial ones (nuclear), which may reduce emissions faster and cheaper.

Third, government investment may crowd out the private sector in two ways. If prospective investors in a project without government financing think they are *competing* against a project that has won lower-cost backing from government, they will be less likely to put up funds. Therefore, government funds may distort investment flows towards projects the managers of the bank believed would be most profitable and reduce the total amount of private capital in the system. This has been particularly prevalent in Brazil's bio-fuels sector, which has shown explosive growth in recent years. Yet the vast majority of the financing for this growth has come from the state development bank, BNDES. Commercial banks in Brazil have lent very little money to the industrial sector, preferring to lend to consumers, because BNDES takes up so much of the market.[68]

Crowding out can also occur within the project itself. The government finance can crowd out private money at the individual project level too. If the remit of the fund is to maximise returns, it should supply as much finance as possible to the most profitable projects, which pushing private sources of finance to one side. Proponents argue that to prevent crowding out the private sector, the bank should wait for private investors who originate, carry out due diligence, price and promote the

68 The Economist, 'Brazil's development bank: nest egg or serpent's egg?' 5 April 2010.

investments to the government fund. The bank should also only look to invest for commercial rates of return, commensurate with the private sector.[69] This may increase the total amount of capital available for projects, but it would not reduce the cost or risk of investment, and would therefore have a limited 'supply push' impact on the total amount of infrastructure constructed. Conversely, if the bank was given a remit that prevented it from picking winners, and insisted that it made returns on the capital, it may end up making it harder for it not to crowd out private sector financing.

69 BVCA, 'Considerations for creating a UK green investment bank', March 2010.

: 8 Conclusion

European countries face immense challenges in responding to the challenges of tackling climate change within a timescale which responds to the forecasts of scientists about the speed with which carbon emissions need to be reduced. Each country faces its own individual challenges in terms of the scale of carbon emission reduction required as a result of the extent of its own reliance on fossil fuels as well as its geographical location in terms of the potential use of different renewable technologies (eg Italy will place greater reliance on solar power and less on offshore wind as a source of renewable energy than the UK).

Demand side policies are of critical importance to provide the incentives required for investment in renewable technologies. A carbon tax/carbon floor price on its own is unlikely to provide sufficient incentive at an economic price to incentivise the scale of investment required. Indeed given the speed with which investment is required to meet the EU renewable obligation by 2020 many countries, such as the UK, have little choice but to adopt a feed in tariff regime which is technology specific. It is recognised however that, without this binding time constraint, using a fixed price approach to provide greater price certainty for investors would be likely to be less economically efficient than a fixed quantity approach of the type used with Renewable Obligation Certificates.

Supply side policies to encourage investment in energy infrastructure are in our view of less importance than demand side policies. Whilst imperfections in the market for finance for investment in energy infrastructure do exist, particularly post the financial crisis, there is not in our view a general problem of lack of finance for good, economic projects. The market is already responding to deal with some of the imperfections which have emerged, such as through the collapse of the monoline insurance market for project bonds. There is some evidence however that there may be a particular problem connected with project development/commercialisation risk for offshore wind projects due to the bespoke nature and scale of many of these projects. There may therefore be the need for government (or government owned entity such as a GIB) to provide some project insurance in this phase of development of a project.

We are not convinced however that there is a more general problem of lack of financing capacity for green investment throughout Europe as some proponents of a GIB in the UK are suggesting. We consider that the staged approach to the formation of a GIB in the UK is an appropriate one with the development of new financing products (such as that being developed by Hadrian's Wall Capital) to deal with elements of construction risk being kept under review in case a more proactive approach by Government and the GIB, such as the issuance of 'green bonds', is required.

There is also a case for government intervention in the form of equity investment (or even grants) at the stage of deployment in a pilot and early stage commercialisation of a project – particularly where the scale of investment is large. Examples of this might include early stage CCS technologies and early stages of offshore wind and tidal power generation. However, one should not underestimate the risks of this form of intervention as it can often be the start of a slippery slope towards more wide ranging government intervention which then risks promoting uneconomic technologies; great care needs to adopted in its use.