



## The basic economics of low-carbon growth in the UK

Mattia Romani, Nicholas Stern and Dimitri Zenghelis

### Policy brief

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## Executive summary

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The UK has committed to a transition towards a low-carbon economy. This transition could not only contribute to the management of the immense risks posed by climate change, it could also be, with good policy, intensely creative and full of opportunity. This policy must be founded on sound economics, which embodies robust and dynamic analysis of the costs, benefits and risks associated with both low-carbon growth and the alternatives. This paper sets out some of the essential economics upon which UK public policy for low-carbon growth should be based. It points out first that some standard models used in policy analysis are structured in ways that are inherently misleading. Second, it argues that the expenditure involved in making the transition to a low-carbon economy must be analysed as an investment, rather than being seen it simply as a net cost or solely as a direct cost to the public purse. Third, it emphasises that this investment can drive an economic recovery. Fourth, it makes clear that the transition to the low-carbon economy is likely to be dynamic, innovative and a period of strong growth. And fifth it highlights the importance of the credibility of policy in fostering new investment.

**1. Understanding the basic economics of low-carbon growth.** It is important to understand what the full, dynamic economic costs, benefits and risks (including those of alternative paths) of the transition to low-carbon growth are likely to be for the UK. This means recognising the shortcomings and limitations of some of the existing economic analyses based on narrow general equilibrium modelling, or on models that take a limited view of the nature of innovation and learning, and which do not account appropriately for the range of benefits and costs associated with low-carbon investment. Such analyses and models, which are

sometimes used within government departments, are not an adequate basis for decision-making. In particular, much of the more simplistic general equilibrium modelling does not usually reflect four fundamental aspects of the policy problem. These are: the value of emission reductions; the potential for efficiencies in energy and other areas to cut costs; the scope for learning and innovation; and the value of energy security. They also fail to model the complex dynamics associated with inertia and path-dependency whereby policy choices made early on have the potential to lock in infrastructure, steer technological innovation and change perspectives in a way that can radically alter the state of the economy being modelled. By failing to take these elements into account some models predetermine the outcomes and can lead to highly misleading and dangerous conclusions, including the entrenchment of high-carbon assets which would later have to be scrapped, and limiting low-carbon innovation. Growth would be undermined, and the UK would remain exposed to risks associated with volatile fossil fuel prices, to the risks of reduced access to future cleaner markets, and of lagging behind the new technological competition. And eventually the immense risks from unmanaged climate change would probably derail high-carbon growth across the world.

**2. The scale and nature of investment required to generate low-carbon growth.** The Stern Review and its follow-up analysis estimated that the incremental global investment required to move to a low-carbon economy is in the range of 1-2% of GDP per year. This is sometimes misinterpreted as an overall net cost of emissions reductions and as a direct cost to the public purse. Both interpretations are mistaken. The Review is clear in describing this expenditure as investment

and in suggesting how it can both have a strong and positive impact on growth and provide further benefits beyond the crucial reduction of the risks of climate change.

**3. Recovery by investing in the real growth story.** The main driver of the growth necessary to boost employment and public finances in this period of economic recovery in the UK is likely to be investment. The key issue preventing a rebound in investment is a lack of confidence to invest rather than a lack of liquidity. One of the easiest ways to stimulate growth and set the public finances on the path to sustainability is to unlock this record level of private saving rather than drawing on scarce public funds. Credible long-term policy signals could leverage finance and unlock private investment in renewable energy, smart networks and communities, energy efficiency and low-carbon vehicles on a great scale.



**4. The lessons from economic history and industrial revolutions.** The history of previous industrial revolutions indicates clearly that learning and innovation can boost economic growth. Many in the private sector recognise that locking in high-carbon technologies or hesitating in commitment to low-carbon technologies is a very risky strategy in relation to access to future opportunities and markets. And they understand from their own work in technology and energy efficiency what can be achieved, in some cases rapidly, with the right kind of focus and intelligent use of markets. History tells us also that early movers are rewarded with higher gains for their economies. The overlap of the clean technology revolution with the revolution in information and communication technologies can offer a particular boost and opportunity to the UK

with its comparative advantage in knowledge and research.

**5. Credibility, confidence and future UK growth.**

The Government has committed to making the transition to low-carbon economic growth. It must continue to show clear decision-making on a range of policy issues, as it has done by following the advice of the Committee on Climate Change on the UK's fourth carbon budget, in line with the long-term objective of making the transition to a low-carbon economy. Significant investment is required in UK energy infrastructure over the next 10 years. Failing to show clarity and confidence now, for instance by being shaky, or appearing shaky, on carbon budget commitments, will damage private sector investment in low-carbon technologies and the prospects for growth, and thus, for employment. Weak or confused government policy, ignoring the multiple market failures in this key area, undermines markets and entrepreneurship, and the ability of the UK to embrace the real growth story of the future. Uncertainty merely raises the cost of any given investment.

There must be tough and serious economic analysis of the management of the transition to the low-carbon economy. There will be costs and difficult decisions. Costs are not saved and investment is not promoted by procrastination or by capture by narrow interests. With careful analysis, we can get to grips with the real issues. There is a great opportunity for the UK to lead in the growth story of the future. This is a time both for decisiveness and for careful and serious economic analysis of difficult questions. We must combine the sense of urgency with the economics that gets to grips with the substance of the



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challenge. An approach which deliberately excludes the key issues is surely inadequate and unacceptable. There are key analytical and policy issues that are not easy but can be addressed; a narrow and simplistic approach will not do. We should improve our understanding of: how to design policy to promote low-carbon growth in a way that takes careful account of the risks and of the dynamics of costs and benefits; how macroeconomic developments are likely to affect the pace and shape of the transition; and how the lessons of past industrial revolutions - and failures to innovate – can inform good policy. There is great potential, so let us engage with the challenges now and not delay or obfuscate.

# The basic economics of low-carbon growth in the UK

Mattia Romani, Nicholas Stern and Dimitri Zenghelis\*

## 1. Understanding the basic economics of low-carbon growth

It is important to understand what the full, dynamic economic costs, benefits and risks (including those of alternative paths) of the transition to low-carbon growth are likely to be for the UK. This means recognising the shortcomings and limitations of some of the current economic analyses. Narrow economic analysis has its place, but if used as the basis for a comprehensive assessment of the costs of low-carbon policies, it risks misunderstanding not only the nature of the investment but also the logic of the low-carbon transition itself. This is because such an approach often misses the key underlying economic issues and analytical approaches that are central to the transition and to policy-making. Specifically, many computable general equilibrium models are inadequate for getting to the heart of the issue because in addition to omitting much of the story of energy efficiency, they leave out learning and innovation in the economy as a whole.<sup>1</sup> The results are essentially predetermined by these key omissions. Assuming away learning and innovation often makes it inevitable that models project increased macroeconomic cost due to the reallocation of investment from existing patterns (if those patterns are assumed to be efficient). This

oversimplification means that questions are sometimes specified wrongly in terms of growth being traded off against environmental action. Such models fundamentally miss four important elements:

- *The value of emissions reductions.* The avoided emissions have great value – this has been discussed extensively in the academic literature and is not the main topic here but must not be forgotten. The costs of unmanaged climate change are potentially immense. Sometimes, they are not honestly and explicitly recognised in analyses and models which are designed mainly for marginal analysis. For example, unmanaged climate change could lead to mass movements of population, possibly hundreds of millions by the end of this century, and much of it towards higher latitudes. It is of course very difficult to model such high impact risks, so some modellers understandably impose a target, such as a warming of 2°C or an atmospheric concentration of greenhouse gases of 450 parts per million of carbon-dioxide-equivalent<sup>2</sup>, and then work out how this is best met. Although this approach is understandable, it should be made clear that corresponding costs are born in order to prevent future climate impacts which could severely derail and reverse growth down the line. The implied benefits of such action are potentially immense.

\* Lord Nicholas Stern is I.G. Patel Professor of Economics and Government at the London School of Economics and Political Science, and Chairman of both the Grantham Research Institute on Climate Change and the Environment and the Centre for Climate Change Economics and Policy. He was previously the head of the UK Government Economic Service (2003-2007) and the Chief Economist at the World Bank and at the European bank for Reconstruction and Development. Dr Mattia Romani is visiting Senior Research Fellow at the Grantham Research Institute and Senior Expert at McKinsey and Co. He was previously with Shell International. Dimitri Zenghelis is Visiting Senior Research Fellow at the Grantham Research Institute and Senior Economist at Cisco. He previously worked on modelling at HM Treasury and with the Stern Review team. We are grateful to Alex Bowen, Chris Duffy, Tim Foxon, James Rydge and Bob Ward for their comments. The arguments set out in the paper are those of the authors and not necessarily of the organisations with which they are associated.

<sup>1</sup> In the jargon of modern economics, they ignore the foundations of “endogenous growth”. For a review of these issues see Koehler et al (2006). See also references in subsequent footnotes.

<sup>2</sup> A target of 2°C is an increase in global average temperature relative to the mid-19th century level, where the target is sometimes defined in terms of a probability, e.g. a 50% chance of avoiding a warming of more than 2°C (Bowen and Ranger 2009). A target of 450 parts per million of carbon-dioxide-equivalent is sometimes defined in terms of a long-run stable atmospheric concentration of greenhouse gases.

• *Efficiency, cost savings and market failures.* For example, lack of information and apparent differing incentives between a landlord responsible for investing in energy efficiency and a tenant responsible for paying the energy bills, is an example of market failures that often prevent investment in efficiencies which reduce emissions and cuts costs. Many possibilities for improving energy and other efficiencies in companies and elsewhere have been missed through lack of managerial focus (for examples, see section 3). And, of course, there is the fundamental market failure where the price of products and services that involve emissions of greenhouse gases do not take into account the costs of damage they potentially cause through climate change. Investment is allocated wrongly in the economy due to such market failures, but these are not taken into account by many economic models.

• *The impact of learning and innovation on economic growth.* For example, introducing a tough standards for greenhouse gas emissions from cars makes innovation in energy efficiency, electric vehicles and renewable generation more profitable because greater policy clarity underpins commitment to and profitability in new markets, and provides for economies of scale. This in turn prompts innovation, demonstration, experience and learning, which bring down the cost of the relevant technologies and processes, thus making them more attractive to adopt. This then leads to further innovation, demonstration, and experience.

Ultimately the degree of cost reduction through learning is an empirical question, but it seems plausible to postulate that learning opportunities from new technologies will be greater than those still accruing from established, mature conventional fuel technologies they replace (and for some evidence see, for example, chapters 9-12 of the Stern Review<sup>3</sup>).

• *The savings associated with a diversified energy system* in terms of energy security and reduced vulnerability to fossil fuel price shocks.<sup>4</sup>

For these reasons, the narrow approach of much of the modelling of the economics of low-carbon growth is highly misleading in that it simply avoids the economic issues at stake. The failure to address the dynamics of innovation and development is particularly troubling. The choice of what infrastructural and technological innovation path to establish or lock-in for the economy has the potential to substantially change the future state of the world.<sup>5</sup> This feature of the real world is missed by models which are largely static or with exogenous steady-states. Indeed, 'lock-in' can be cultural as well as technological. For example, many Scandinavian cities favour the use of bicycles. This reflects the presence of an established infrastructure for these activities, which is driven, for example, by popular demands and policies to encourage cycle lanes. A good infrastructure then makes cycle use easier and a

<sup>3</sup> Stern (2007).

<sup>4</sup> Energy security should be defined and analysed with care. In some countries it might be seen in terms of more extensive use of domestic high-carbon fuels such as plentiful coal reserves, although that means vulnerability to prices and to possible future international sanctions. Policy must also address problems such as the intermittency of some renewable energy sources, which requires a comprehensive policy approach to energy generation, distribution, storage and demand. The subject requires close attention and a broad perspective. Diversity of source is, however, a basic principle for security.

<sup>5</sup> In the economic jargon we have 'path dependency'. For an analysis of technological lock in see Unruh (2006) and Foxon (2007).

more 'normal' choice. There is a 'chicken and egg' virtuous cycle which policy can trigger. Once a city or a country embarks on a track favouring such activities, it is hard to turn back: the city or country is set on a new path and the dynamics of the model change. This means that early choices make a big difference. In the economic jargon we have 'path dependency'. For an analysis of technological lock in see Unruh (2006) and Foxon (2007). What we need to understand is what it means, for the wider economy, to go through a period of profound learning and transformation based on investment and innovation in its energy and industrial structure. Once the economic analysis is set out in a way that gets to grips with the real issues, conclusions are reached which can be radically different from those predetermined by the narrow approach to modelling.<sup>6</sup> That said, it should be noted that many models that do not explicitly incorporate strong dynamics in learning, still conclude that urgent action is cost-effective in reaching a path to climate sustainability.<sup>7</sup> These issues were addressed in the Stern Review, particularly in terms of the effects of learning and innovation and the benefits derived from being at the forefront of the low-carbon energy and industrial revolution. The evidence of these past five years points to a stronger and faster impact of innovation than was expected at the time of the Review.<sup>8</sup> See for example the radical changes in the costs of solar power, the rapid diffusion of the hybrid electric car, the opportunities for transport and storage of electricity, the development of

second generation biofuels, etc. The logic and narrative are clear: investing in this transition will incur gross costs but will lay the foundation for growth by reducing cost in the future. Further, it can create immediate benefits, such as energy efficiency and reductions in other environmental risks, as well as reducing climate risk. Failing to invest will trap us in an obsolete high-carbon economy that will handicap future competitiveness (in the context of a cleaner world), and subject itself to the vagaries of fluctuations in fossil fuel prices.<sup>9</sup> Eventually high-carbon growth will choke itself on the inevitable and potentially devastating consequences of climate change. The questions then become what is the most cost-effective approach to taking action and what the pace of such action should be? We shall return to these questions in sections 3, 4, and 5.

<sup>6</sup> Acemoglu et al (2009).

<sup>7</sup> See for example the ADAM project (Adaptation and Mitigation Policies: Supporting European Climate Policies <http://www.adamproject.eu/>); the RECIPE project (<http://www.pik-potsdam.de/recipe/>); and the Stanford Energy Modeling Forum (<http://emf.stanford.edu/>).

<sup>8</sup> OECD (2010).

<sup>9</sup> Roadmap 2050 (2011) showed that in the case of a fossil fuels spike (a doubling of fossil fuel prices for 3 years) a decarbonised economy would save Europe over €70 billion (£60 billion) a year for the duration of the crisis thanks to its reduced reliance on fossil fuels.

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## 2. The scale and nature of investment required to generate low-carbon economic growth

The Stern Review provides some estimates of the investments required to embark on the transition to a low-carbon economy. It found that incremental investment and operating cost needs are globally approximately 1% of GDP p.a. to meet a stabilisation target of 500-550 parts per million of carbon-dioxide-equivalent.<sup>10</sup> This estimate was then revised upwards to 2% of GDP p.a. to reflect the latest scientific evidence on the need to reduce emissions more quickly and drastically to meet a target of 500 parts per million of carbon-dioxide-equivalent.<sup>11</sup> These are estimates of the magnitude of necessary investments across the world economy to limit climate risks, not as some have misinterpreted, an overall net cost of emissions reductions or costs to the public purse.<sup>12</sup> While not modelling it in detail, the Review's analysis also describes how the impact of such investment, in particular through associated learning and innovation, on growth could be strong and positive. In our view, the analysis has stood the test of time, both in the estimation of the necessary scale of change and investment, and in the description of the potential benefits from the investment beyond the fundamental reductions it provides in the immense risks of climate change. The scientific evidence that has emerged on the risks of climate change in the five years since the Stern Review was published looks ever more troubling.<sup>13</sup>

<sup>10</sup> Stern (2007), page 267.

<sup>11</sup> For example, see Stern (2009).

<sup>12</sup> The misunderstanding is occasionally found in media discussion or in intra-governmental policy discussion.

<sup>13</sup> For example, there is mounting evidence that absorption of carbon dioxide in some oceans is falling more so than predicted by many models (Le Quéré et al 2009), emissions are growing faster than we thought (Le Quéré et al 2009; Friedlingstein et al 2010), and that the melting of Arctic sea ice and ice sheets and damages to ecosystems are happening faster than we thought (Bowen and Ranger 2009).

### 3. Recovery by investing in the real growth story

Now is the time to invest. Our economy has spare capacity and there is a stock of financial resources available. The issue is lack of confidence to invest rather than a lack of liquidity. The private sector in the UK generated a surplus of £110 billion in 2010.<sup>14</sup> By contrast total UK investment in clean energy by both the public and private sectors was just £2 billion, according to a report by Pew Charitable Trusts.<sup>15</sup> Figure 1 shows net borrowing (the balance between investment and saving or, equivalently, income and expenditure) for each sector, private and public. The current account aggregates both balances and measures the excess of saving over investment at the whole economy level.<sup>16</sup>

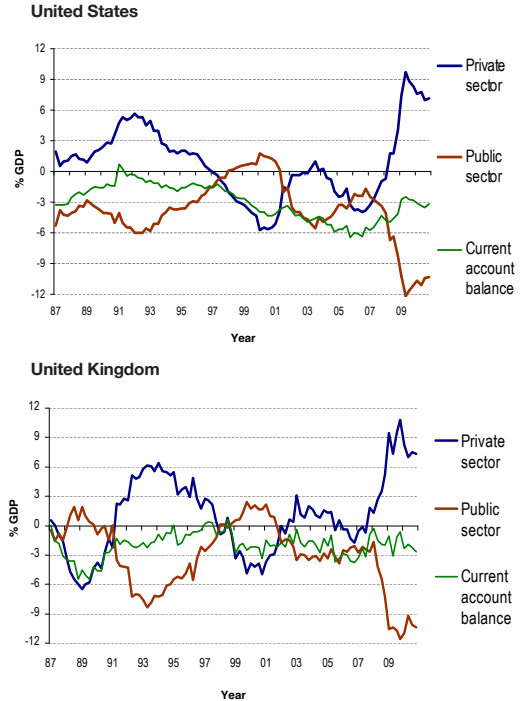


Figure 1: Sector financial balances, % of GDP  
 Source: United States Bureau of Economic Analysis and UK Office for National Statistics

<sup>14</sup> Private surplus refers to the National Accounts definition of total private income minus total private spending (consumption and investment). It is the private sector counterpart to the public sector (fiscal) deficit, and the difference between the two comprises net borrowing from abroad. See: Zenghelis (2011).

<sup>15</sup> The Pew Charitable Trusts (2011).

<sup>16</sup> Any (relatively small) statistical errors are captured in the 'balancing item' which ensures that the current and capital accounts sum to zero.

One of the easiest ways to stimulate growth and set the public finances on the path to sustainability is to unlock the record pool of private saving rather than drawing on scarce public funds. Credible long-term policy signals would leverage private investment in renewable energy, smart networks and communities, energy efficiency and low-carbon vehicles. Strong carbon prices can raise public revenue. Hesitation and nervousness in policy undermine confidence, as is all too evident from the recent instability of capital and energy markets.<sup>17</sup> These markets are policy-led, and thus have the potential to provide a degree of much needed investor certainty at a time of general uncertainty in the macroeconomic environment, which is holding back investment. Now is the time to lay out the comprehensive policy framework that can create the clarity and confidence in the future of low-carbon technologies that the private sector seeks.<sup>18</sup> With output remaining below capacity and the cost of capital at historically low levels, there is very little fear of ‘crowding out’ alternative investment, or displacing jobs. Indeed, the best time to invest in a sound long-term growth strategy and to address the basic market failures hindering investment is precisely when economic activity is slow and the competition for natural and human resources is relatively reduced. This line of argument on policy was a central outcome of the G20 Seoul Business Summit in November 2010, where the heads of 120 of the largest companies

in the world (including companies key to the UK economy, such as HSBC, Standard Chartered, ArcelorMittal, Anglo American) asked G20 Heads of State to boost investment now by sending clear, credible and long-term signals to markets about pricing carbon and reducing emissions.<sup>19</sup> Early evidence indicates that many of these opportunities are real and short-term as well as long-term, and, in particular, that radical improvements in energy efficiency can often be achieved quickly.<sup>20</sup>

Now is the time to build the foundations of a sustainable and dynamic medium-term growth path. When we came out of the (dotcom) bubble a decade or so ago, the foundations for the next bubble were laid by attempting to revert to business-as-usual and failing to focus on investment. This could hardly be described as a sensible growth policy.

When achieved, low-carbon growth will be more energy-efficient, more energy-secure, more equitable, safer, quieter, cleaner and more bio-diverse. It will be far more attractive than what has gone before. The substantial benefits for living standards, across a whole range of dimensions, are of a kind rarely captured by the narrow economic models currently used inside government departments.

<sup>17</sup> Bowen and Stern (2010).

<sup>18</sup> Zenghelis (2011).

<sup>19</sup> Seoul G20 Business Summit - Joint Statement by Participating Companies (November 11th, 2010, <http://www.seoulg20businesssummit.org/en/>).

<sup>20</sup> Marks & Spencer plans to be carbon neutral by 2012 using food waste to generate power (<http://plana.marksandspencer.com/media/pdf/planA-2010.pdf>). The Chief Executive Officer of Walmart told

1,000 suppliers in China in 2008 that high environmental and energy saving standards would be mandated - supply chains savings are crucial - and Walmart is committed to ‘zero waste’ and ‘100% renewable energy’ (<http://www.wal-marchina.com/english/walmart/index.htm>). Dupont is saving more than US\$2 billion a year from energy efficiency initiatives, as George Hadi Santoso indicated in his presentation to Infrastructure Indonesia Conference 2011 on 14 April

(<http://infrastructureindonesia2011.com/CONFERENCE140411/CLEANENERGY140411/Mr%20George%20Hadi%20Santoso%20-%20Country%20Manager%20-%20DuPont%20Indonesia/DuPont%20Path%20to%20Sustainability%20140411%20HM.pdf>). British Telecom saved £1.5 billion between 2002 and 2006 by reducing energy costs (Esty and Winston 2006).

## 4. The lesson of economic history and industrial revolutions

Previous industrial revolutions point to the great potential for growth from the coming energy and industrial revolution. This new revolution and the associated transition to low-carbon growth constitute a very attractive path. Provided governments deliver long-term policy credibility and prompt the creation of new products in a competitive environment, this is likely to bring two or three decades of dynamic, innovative and creative growth, and large and growing markets for the pioneers.<sup>21</sup> Given the evidence for the magnitude of growth effects of previous industrial revolutions, such as those associated with the spread of railways or electricity, the growth potential of this new energy and industrial revolution could be major.<sup>22</sup> Waves of innovation have succeeded one another from the 18th century, and many have created unexpected sources of wealth and economic growth.

This particular wave of innovation associated with low-carbon technology has the additional advantage of overlapping with the revolution in information and communications technology, which is still in full swing. There is no previous example of a new technology whose price has fallen so precipitously, or which has diffused through the economy as swiftly, as innovations in computing and mobile communication.<sup>23</sup> This allows not only for great opportunities in energy

management and efficiency, but also for unprecedented speed in sharing and spreading knowledge and skills across the world. The UK could play a particularly important role at the intersection between these two areas of innovation, given its comparative advantage in education and research.

Moving early in the race to a low-carbon economy is likely to entail risks, and second movers often have the advantage of learning from pioneers' mistakes by not pursuing costly dead-ends. However, moving late is likely to incur far more substantial disadvantages in a world that is destined to become carbon- and resource-constrained. In general, early movers will reduce costs associated with low-carbon technologies more quickly, and will become exporters of goods, ideas, knowledge and skills.<sup>24</sup> Furthermore, in a world in which the varying pace of action creates a maze of different carbon prices and related regulations across countries, some tariff (or other border) adjustment based on the carbon content of goods is likely to be politically attractive to many countries.<sup>25</sup> The risk of 'carbon dirty' goods (arising in part from delay and lock-in) being shut out of global markets is real.

Lastly, strong action and the associated international credibility with our partners around the world can keep us close to key players in the world economy. China, South Korea, India, South Africa, Brazil – to mention a few – are taking the



<sup>21</sup> Perez (2002).

<sup>22</sup> In the UK the revolution in information and communications technology contributed as much as one percentage point a year to growth rates in the period between 1990 and 1998. For a comprehensive overview of the impact of previous industrial revolutions on economic growth in the UK, see Chapter 3 of IMF (2001).

<sup>23</sup> Crafts (2010).

<sup>24</sup> Germany, Denmark, US and China have gained substantially by investing early on innovation in wind and solar technologies (see presentation on 'Geopolitics of Clean Energy' by Michael Liebreich, Chief Executive of Bloomberg New Energy Finance, 1 June 2011: <http://bnef.com/Presentations/download/68>).

<sup>25</sup> Such policies would not be without foundation in basic economic theory. For example, see Houser et al (2008).



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threat of climate change very seriously, recognising the opportunities for low-carbon growth and rapidly transforming their economies.<sup>26</sup> China has moved decisively to embrace low-carbon growth, notably in its stimulus package of 2008-09 but also, and more recently, in its outline for the 12th five-year plan. This plan sets strong targets for energy efficiency and emissions intensity.<sup>27</sup> China and other countries recognise that the 'green race' has already begun. Those that deliberately opt out may find they miss out on the fastest growing markets.

<sup>26</sup> Different countries are at different stages and moving more or less rapidly. The most striking example of rapid change is, perhaps, the Chinese 12th Five Year Plan approved in March 2011. For a comment on its implications for the world economy see Stern (2011).

<sup>27</sup> Stern (2011).

## 5. Credibility, confidence, future growth and the fourth carbon budget

We must remember, however, that this energy and industrial revolution requires policy on carbon. The UK sends a clear message by passing legislation to adopt the fourth carbon budget for proposed by the Committee on Climate Change for the period between 2023 and 2027.<sup>28</sup> Strong implementation is crucial. Good government policy sets the framework for the private sector to invest on the scale required, and is the driver of change. Setting ambitious and credible targets for emissions, fostering the network infrastructures which enable innovation (e.g. smart low-cost grids), and laying out sensible regulation and incentives are prerequisites for markets to function well.

Rejecting government intervention, and ignoring the multiple market failures that are at the heart of this story, undermines markets and cripples entrepreneurship. Getting the policy right means unleashing the power of markets to generate the Schumpeterian creative destruction where new, more efficient firms and technologies drive out old ones, thereby increasing overall economic growth and welfare. To avoid the policy decisions necessary to deal with the key market failures here is, essentially, to be anti-market and anti-growth. UK business has recognised the investment challenge that the UK faces over the next few decades if it is to be a front-runner in the low-carbon revolution.<sup>29</sup> It demanded that the UK government show leadership and implement the

clear and strong policies necessary to foster this investment.<sup>30</sup> UK business also recognises that the UK is not the only country going through such a transition, and competition for such capital will be intense: it will flow to the countries that establish sound and credible policies.

*'To boost the UK's attractiveness as an investment destination, there is much the government can, and must, do. Failing to secure the right investment levels would not only result in the UK falling behind its competitors and relinquishing economic advantage, but it will seriously impede our ability to hit our climate change targets.'*<sup>31</sup>

Most studies show that the risk that climate action will prompt a relocation of carbon-emitting activities abroad is small and manageable: it is confined to a narrow set of carbon-intensive tradable industries.<sup>32</sup> Some have raised concerns for UK industries such as steel and aluminium. With strong carbon policy now, such industries will find themselves in a much better competitive position in 10 years time in a world which is cleaner and where many countries understandably wish to avoid importing carbon: if the UK moves early it can, through learning and innovation, reduce the cost of alternative power technologies and improve efficiency. This is sensible, forward-looking investment. It does not seem wise to make the prospects for growth captive to the short-term concerns of a small set of industries; that would surely be anti-growth for the economy as a whole. Narrow, short-term competitiveness issues for some industries must, and can, be managed through sectoral agreements or, through the

<sup>28</sup> 'The prize, perils and price of China's plan' (Financial Times, Friday April 28th 2011 <http://www.ft.com/cms/s/0/7447df7c-71c6-11e0-9adf-00144feabdc0.html#axzz1M2i7LxY5>).

<sup>29</sup> The CBI (2009) estimates that the UK unnecessarily wastes £15 million a day on energy from households and businesses.

<sup>30</sup> See Green Investment Bank Commission (2010) and CBI (2011b).

<sup>31</sup> CBI (2011a).

<sup>32</sup> Hourcade et al (2007); Committee on Climate Change (2008).

introduction of border adjustments for carbon price differentials or controlling the pace of movement to auction of emissions permits and in other ways. They should not stop us from making sound long-term investments which will benefit the economy across the board, including those industries, in the medium term.

Policy must begin by correcting the biggest market failure the world has seen – failure to price greenhouse gas emissions. But there are other key market failures which must be dealt with at the same time if we are to avoid shackling innovation and entrepreneurship. Thus a second crucial market failure results from the public nature of ideas – those who innovate and demonstrate provide learning for others. Policy should help create the conditions for fostering and sharing knowledge about the new technologies. Because of the urgency for action and the apparent strong learning potential, this issue, although general, is of special importance in this context. A third market failure occurs because capital markets are limited in their ability to manage the risks associated with investment in these technologies (especially important in this case because of the scale and long-term nature of much of the investment). A fourth set of market failures are associated with network externalities, and can be overcome by enabling access to networks, such as new and better grids or public transport). A fifth set of market failures are associated with information, which can be overcome by creating awareness of the emission properties of what we buy, consume and use, and the options available for emission reductions. All of these are basic to markets playing their role efficiently and effectively: a carbon price is crucial but on its own is not enough.

The Committee on Climate Change estimates that the cost of meeting the UK's target of reducing its emissions of greenhouse gases by 80% by 2050 compared with 1990 is 1-2% of GDP.<sup>33</sup> There will be major investments to be made in the coming years and some short-term increase in energy prices is inevitable. Good policy must focus on sound management of these costs, including in relation to income distribution, and this will require careful analysis and scrutiny. But the overall cost of action will be far higher if action is delayed and then rushed. The most cost-effective approach is to manage actively the transition to a low-carbon economy by taking advantage of the depreciation of existing capital and inducing innovation in new technologies early on so that their costs fall through time. There are grave dangers to growth from indecision and procrastination, not simply by falling behind in technology, but also by being shut out of future markets. Important issues will need to be carefully examined and addressed, such as energy portfolio choices and their timing, including the speed of deployment of on- and off-shore wind, the role of gas and nuclear power, the financing and management of carbon capture and storage (CCS),<sup>34</sup> and so on. Important decisions on, for example, developing network infrastructure will need to be taken – for example, a smart and efficient European grid could play a vital role in promoting renewable energy and energy efficiency, in reviving the European economy and in helping European cohesion.

We must also recognise that there is a risk that the valid and crucial arguments concerning market failures are twisted and used as an excuse to introduce damaging and inefficient policies. This real concern argues for the careful design of open and non-discriminatory policy frameworks, which

<sup>33</sup> Committee on Climate Change (2010).

<sup>34</sup> The technology of CCS itself is relatively well tested and understood but there are major challenges and learning necessary in moving to scale.

reduce incentives for wasteful 'rent capture' by influential vested interests, whether they be in hydrocarbons, specific renewables, nuclear or elsewhere. At the same time we must never make the basic error of confusing the reasonable wish for the level-playing field with the absence of policy to deal with the critical market failures.

## 6. Conclusion

There must be tough and serious economic analysis of the management of the transition to the low-carbon economy. There will be costs and difficult decisions. Costs are not saved and investment is not promoted by procrastination or by capture by narrow interests. With careful analysis, we can get to grips with the real issues. There is a great opportunity for the UK to lead in the growth story of the future. This is a time both for decisiveness and for careful and serious economic analysis of difficult questions. We must combine the sense of urgency with the economics that gets to grips with the substance of the challenge. An approach which deliberately excludes the key issues is surely inadequate and unacceptable. There are key analytical and policy issues that are not easy but can be addressed; a narrow and simplistic approach will not do. We should improve our understanding of: how to design policy to promote low-carbon growth in a way that takes careful account of the risks and of the dynamics of costs and benefits; how macroeconomic developments are likely to affect the pace and shape of the transition; and how the lessons of past industrial revolutions - and failures to innovate - can inform good policy. There is great potential, so let us engage with the challenges now and not delay or obfuscate.

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