

Energy transitions and uncertainty: creating low carbon investment opportunities in the UK electricity sector

Article (Published Version)

Bolton, Ronan, Foxon, Timothy J and Hall, Stephen (2016) Energy transitions and uncertainty: creating low carbon investment opportunities in the UK electricity sector. *Environment and Planning C: Government and Policy*, 34 (8). pp. 1387-1403. ISSN 0263-774X

This version is available from Sussex Research Online: <http://sro.sussex.ac.uk/59634/>

This document is made available in accordance with publisher policies and may differ from the published version or from the version of record. If you wish to cite this item you are advised to consult the publisher's version. Please see the URL above for details on accessing the published version.

Copyright and reuse:

Sussex Research Online is a digital repository of the research output of the University.

Copyright and all moral rights to the version of the paper presented here belong to the individual author(s) and/or other copyright owners. To the extent reasonable and practicable, the material made available in SRO has been checked for eligibility before being made available.

Copies of full text items generally can be reproduced, displayed or performed and given to third parties in any format or medium for personal research or study, educational, or not-for-profit purposes without prior permission or charge, provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way.

Energy transitions and uncertainty: Creating low carbon investment opportunities in the UK electricity sector

Environment and Planning C: Government and Policy
0(0) 1–17



© The Author(s) 2015

Reprints and permissions:

sagepub.co.uk/journalsPermissions.nav

DOI: 10.1177/0263774X15619628

epc.sagepub.com



Ronan Bolton

Science Technology and Innovation Studies, School of Social and Political Science, University of Edinburgh, UK

Timothy J Foxon

Science Policy Research Unit, University of Sussex, UK

Stephen Hall

Sustainability Research Institute, School of Earth and Environment, University of Leeds, UK

Abstract

This paper examines how actors in the UK electricity sector are attempting to deliver investment in low carbon generation. Low carbon technologies, because of their relative immaturity, capital intensity and low operational costs, do not readily fit with existing electricity markets and investment templates which were designed for fossil fuel based energy. We analyse key electricity market and infrastructure policies in the UK and highlight how these are aimed at making low carbon technologies ‘investable’ by reducing uncertainty, managing investment risks and repositioning actors within the electricity socio-technical ‘regime’. We argue that our study can inform contemporary debates on the politics and governance of sustainability transitions by empirically investigating the agency of incumbent regime actors in the face of uncertainty and by offering critical insights on the role of markets and finance in shaping socio-technical change.

Keywords

Low carbon investment, uncertainty, sustainability transitions, energy

Introduction

An important feature of electricity systems is their capital intensity. Infrastructure assets, whether this is electricity generators, transmission lines or transformers, require significant

Corresponding author:

Ronan Bolton, Science Technology and Innovation Studies, School of Social and Political Science, University of Edinburgh, Old Surgeons' Hall, High School Yards, Edinburgh EH1 1LZ, UK.

Email: Ronan.Bolton@ed.ac.uk

upfront capital investment, the returns from which typically stretch out over many decades. The creation of certainty about long-term economic returns from infrastructure investment has strongly influenced how this sector is governed, and this has been achieved in different ways through the history of modern integrated electricity systems. In the US, for example, privately owned utility companies were granted monopoly rights to supply a defined geographic area, on the basis that their revenues would be tightly controlled by a public regulator, or rate commission (Granovetter and McGuire, 1998; Hughes, 1983). In many European countries, such as the UK, investments of state-owned energy companies were underwritten by national governments (Chick, 2008). In both cases, certainty was created through strong government control (either ownership or regulation) and a vertically integrated industry structure which allowed utilities to plan investments on the basis of relatively predictable demand for electricity in their areas. The primary governance aim was creating institutional structures to ensure security of supply – in the case of electricity systems, literally ‘keeping the lights on’.

The introduction of competitive markets for electricity since the 1980s has fundamentally altered these relationships between governments, consumers, utilities and other private investors. In the UK utilities now compete for customers and a key role of the markets is to incentivise private investment on the basis of price signals. Underpinning the design of electricity markets in the UK was the idea that customer protection from monopoly power and the delivery of cost efficiencies across the industry would be best achieved through competitive forces (Helm, 2003). Since the early 2000s, a third objective of reducing greenhouse gas emissions has increasingly been pursued in the UK. 2008 saw the introduction of the Climate Change Act which set a legally binding target of 80% reduction in emissions by 2050 from 1990 levels. This gives rise to new uncertainties about the role of governments and markets in delivering electricity infrastructure investment in line with public policy objectives of reducing emissions, whilst maintaining security of supply and ensuring affordability of energy services – the so-called ‘energy trilemma’ (Boston, 2013).

This paper examines how, in the UK liberalised context, these new uncertainties are framed and acted upon by government and market actors. The empirical study investigates UK government initiatives to reconfigure electricity markets to create investment certainty for centralised low carbon electricity technologies – notably in ‘mature’ technologies such as nuclear, biomass conversion and onshore wind, but also less mature forms of generation such as offshore wind and carbon capture and storage (CCS). An important ambition of these initiatives has been to attract finance from institutional investors such as pension funds who have not traditionally been involved in direct financing of electricity generation, thus potentially altering the established relationships between government, energy utilities and investors which has characterised the liberalised electricity ‘regime’ in the UK. The rationale for this low carbon investment orientated strategy is that it will reduce the UK’s exposure to volatility in global fossil fuel markets and give certainty to investors that the UK is committed to a low carbon pathway, thus reducing the cost of capital of large infrastructure investment.

We critically analyse this process by relating insights on risk and uncertainty to the literature on sustainability transitions which analyses structural changes to resource intensive socio-technical systems necessary for key societal services like electricity, heating, shelter and transport (Steward, 2012). This body of literature has been criticised for adopting a ‘niche-bias’ which over-emphasises the role of disruptive innovations and bottom-up change processes, and views incumbent actors as largely static and resistive to change (Smith et al., 2005; Winkler and Radcliffe, 2014). Through our empirical study we seek to

provide new insights on how efforts to achieve sustainability transitions are being shaped by incumbent regime actors embedded in existing markets and systems through their efforts to create certainty in relation to large infrastructure investment programmes. We provide an understanding of the emerging relationships between policy, investment and electricity markets, and by illustrating new mechanisms for investment risk allocation between public and private actors we pose critical questions for research on the politics of governance of sustainability transitions.

The paper is structured as follows: In the next section ('Socio-technical regimes and investment uncertainty'), we outline the theoretical framing of the paper. We begin by summarising recent debates in the sustainability transitions literature. We then introduce relevant literature on the topic of uncertainty and discuss how this can inform an understanding of socio-technical systems and investment uncertainty. Section 3 ('Creating low carbon investment opportunities in the UK') contains the empirical core of the paper which describes how government and market actors in the UK are aligning around new electricity investment strategies. This is based on a series of interviews with investor and energy policy actors and an analysis of key documents. In the final section ('Discussion and Conclusions'), we discuss our empirical findings in relation to wider debates about governing sustainability transitions.

Socio-technical regimes and investment uncertainty

The dynamics of socio-technical regimes

Socio-technical regimes, as defined below, form the 'focal unit of analysis' (Smith et al., 2005) in transition studies:

The socio-technical regime forms the 'deep structure' that accounts for the stability of an existing socio-technical system. . . It refers to the semi-coherent set of rules that orient and coordinate the activities of the social groups that reproduce the various elements of socio-technical systems. (Geels, 2011: 27)

Regimes in this sense are 'meso-level' socio-technical aggregates which underpin the delivery of key societal functions such as electricity and transport. 'Regime shifts', or transitions, are not analysed in terms of a single technology or actor, rather the 'change from one socio-technical configuration to another' (Geels, 2002).

There is a stylised account of transitions in the literature which is based on the multi-level perspective of meso level regimes, micro level niches and an external macro level landscape. Transitions have been generally viewed as emergent, unpredictable innovation processes – radical innovations emerge from niches, which are protected and removed from the structural constraints of incumbent regimes. Given the right 'landscape' conditions, e.g. a financial crisis or unexpected disruption, the stability of regime structures are compromised and niche innovations can grow to eventually overthrow the incumbent regime whose capacity to adapt is constrained by a commitment to outdated business models and technologies (Hoogma et al., 2002; Kemp et al., 1998).

However a number of recent studies have argued for a more in-depth analysis of regime processes and how the political dynamics between different actors in a regime give rise to stability or incremental change, whilst blocking more radical change (e.g. Geels, 2014; Karltorp and Sandén, 2012; Meadowcroft, 2009; Ottosson and Magnusson, 2013; Smink et al., 2015; Smith et al., 2005; Stenzel and Frenzel, 2008; Turnheim and Geels, 2013; Winskel and Radcliffe, 2014). For example, Geels (2014) analyses collective action on the

part of UK electricity regime actors including ‘policymakers and incumbent business actors [who] tend to form close alliances because of mutual dependencies’ (p. 26). He illustrates how, as a collective block, regime actors formulate resistance strategies to disruptive innovations by mobilising ‘instrumental, discursive, material and institutional forms of power’ (p. 3). Earlier work by Smith et al. (2005) points to three key factors which influence the ability of regimes to maintain control over transition processes: How ‘selection pressures’ are articulated by regime members, whether regime members possess the resources and capacities necessary for transformation, and finally the extent to which regime responses are coordinated and coherent. They argue that the ability of a regime to respond to changing selection pressures, its adaptive capacity, is ‘a function of the availability of resources and how they are coordinated’ (p. 1492). Regimes with a high adaptive capacity are well resourced and respond in a highly coordinated manner to selection pressures.

It has been highlighted elsewhere that infrastructure investment is a key source of ‘lock-in’ of socio-technical systems (Unruh, 2000). Closing down uncertainty in relation to investment decisions is a key mechanism by which regime actors maintain their dominant position. However, the topic of investment and uncertainty has not been explicitly discussed in depth in the transitions literature. Below we introduce some relevant concepts and strands of thinking on the issue of uncertainty as it relates to markets and investment.¹ Following this we discuss how these insights can be drawn upon to inform our analysis of UK electricity.

Investment and uncertainty

An important starting point in this discussion is the distinction between uncertainty and risk initially made by the economist Frank Knight (Knight, 1921). Risk refers to situations where, although the future outcome is unknown, it is possible to calculate probabilities based on information and knowledge from past experience. Uncertainty, on the other hand, refers to situations where there is inadequate information or capacity to assess likely outcomes. In situations of uncertainty, previous experience cannot be relied upon.

Economic sociologists have stressed the importance of institutional change and the state in managing complexity and uncertainty in markets. The literature on the sociology of markets emphasises the role of institutional adaptation in transforming unknowable uncertainty into measurable and manageable risk. Beckert (1996) is concerned with the ways in which actors ‘reduce the complexity they confront in decision-making processes’ (p. 825), and refers to ‘social devices’ for reducing uncertainty such as social networks and organisational routines which breed familiarity and provide structure to economic exchange. Fligstein (2001) argues that during periods of market transformation and uncertainty, incumbent market actors often prove ‘incapable of providing rules for themselves [and]...in the face of uncertainty and difficult competition, firms find it impossible to solve their collective problems of competition’ (pp. 27, 28). Government interventions in the form of defining property rights, rules of exchange and governance structures create certainty and stability in markets and hence form the basis of socio-technical regimes.

The relationship between uncertainty and institutional transformation is also of concern to institutional economists who argue that the origins of hierarchical governance structures lie in efforts to manage risks and uncertainties associated with effectively organising economic activity in complex markets (Coase, 1937; Williamson, 1985). Institutional economists emphasise the importance of hybrid forms of economic organisation which facilitate information exchange and reduce uncertainty in economic processes. These are situated along the continuum between pure hierarchy and markets, examples include vertical integration in industries, joint ventures and contracts.

Delivering low carbon investment through uncertainty reduction and risk management

This discussion of uncertainty suggests that regime capacity to reduce uncertainty by exerting control over investment is strongly influenced by incumbent actors' collective efforts to manage risks through institutional changes which affect the operation of markets and regulatory frameworks. During periods of uncertainty government intervention is more likely to be required to create the necessary certainty and investment conditions. The specific challenge facing incumbent actors in the UK electricity regime is that low carbon generation technologies, particularly renewables and nuclear power, have different characteristics to conventional fossil fuel based electricity generation technologies. They have higher capital costs but lower running, or marginal, costs (primarily the cost of fuel). This means that they are less compatible with electricity markets designed for conventional technologies. The policy-orientated literature on low carbon investment discusses a range of investment risks which, although common across all technologies, tend to be accentuated for low carbon (Hamilton, 2009, PWC, 2010; Sullivan, 2011, Waissbein et al., 2013). These include:

- The risk of cost overruns at the *construction* stage of a project;
- *Operational and technology* risks such as the durability of the technology in extreme weather conditions, unforeseen maintenance costs, the reliability of wind, solar resources and other feed stocks or the availability of a reliable grid connection;
- *Financing* risks such as the availability of reliable sources capital at acceptable rates of return;
- *Market* risks such as variations in electricity wholesale prices, carbon price or the volume of generation required to meet demand;
- *Policy or regulatory* risks, associated with changes in levels or forms of support available for investment in new generation.

In the following section ('Creating low carbon investment opportunities in the UK'), we will discuss how institutional changes are aiming to manage and allocate these risks so that they are calculable and acceptable for different types of investor and fit with the established investment templates for large scale infrastructure investments. We observe that there is a potential repositioning of actors taking place within the UK electricity regime where, enabled by government interventions to manage risks and create certainty, institutional investors take a more active role in financing low carbon generation investments.

We discuss how a key motivation behind recent government initiatives – Infrastructure UK (IUK) and the Green Investment Bank (GIB) – has been to improve communication and build trust with prospective investors. This relates to Beckert's insights on the role of new 'social devices' in reducing uncertainty. First, we discuss recent government proposals for Electricity Market Reform (EMR) which aim to reduce price uncertainty for investors to managed price risk. This brings to the fore Fligstein's insights and those of institutional economists on the role of government intervention and hierarchy in providing stability in markets during periods of uncertainty.

Creating low carbon investment opportunities in the UK

Methods

The primary source of our empirical study is a series of in depth semi-structured interviews with individuals in the investment and energy policy communities in the UK. Fifteen

interviews were conducted during 2013 (see Appendix), three were with employees of incumbent energy utilities, five with investment professionals (either fund managers or advisers of pension funds and insurance companies), three with individuals who invest in small scale decentralised technologies, one non-governmental organization professional campaigning for more sustainable pensions investment practices, one with a CEO of an investment industry body which promotes sustainable and low carbon investment, and two with officials in key energy focused government agencies who regularly interact with investors.

Interviews lasted between 30 minutes and 1 hour and focused on the nature of interactions between government and investors in relation to EMR, IUK and the formation of a public GIB. All interviews were recorded, transcribed and manually coded according to key emerging themes. Below we discuss on specific energy and infrastructure policy areas which were highlighted by interviewees as particularly pertinent to the maintenance of centralised electricity supply in a low carbon future.

Getting the prices right – Addressing uncertainty in the electricity market

In this section, we discuss how concerns about investment uncertainty have become increasingly central to mainstream energy policy debates in relation to the restructuring of electricity markets.

The UK pioneered the development of liberalised electricity markets in the 1990s with the initial creation of a wholesale market for electricity generation in 1990 and the subsequent introduction of retail electricity markets for commercial and domestic customers. Underpinning this was a view that the previous model of state directed and financed investment was inefficient, leading to higher costs for consumers, and that private investors are best placed to make ‘optimal’ investment decisions (Bolton and Foxon, 2013; Mitchell, 2008). However, since 2010 the UK government have been consulting on and implementing a process of EMR, characterised by significant government intervention designed to stimulate investment in low carbon and balancing generation (including all renewables, nuclear and CCS, and new gas plant) for environmental and security of supply reasons.

The electricity market in the UK, now known as BETTA,² operates on a rolling half-hour basis where the vast majority of trading is conducted bilaterally between suppliers (retail companies who sell to customers) and generators. Suppliers are incentivised to procure adequate volumes to meet their demand for each trading period and generators face penalties if they do not input the agreed amount of power into the grid. A key challenge for these companies is to procure adequate volumes of power to serve demand, but not to oversupply. Partly in order to overcome these risks the large energy companies in the UK have adopted vertically integrated corporate structures and as a result the market is now dominated by six large utilities who both generate and sell power to customers – the ‘big six’.

An unintended consequence of the liberalised market structure was that investment in combined cycle gas turbine (CCGT) plants became the investment of choice. During the 1990s the UK underwent a ‘dash for gas’ when gas consumption for electricity generation increased rapidly³ following the dismantling of the state owned utilities (Bolton and Foxon, 2015; Kern, 2012; Winskel, 2002). This was due to the lower capital costs of CCGTs relative to alternatives, their flexibility in an increasingly dynamic market and the availability of secure and relatively cheap sources of gas from the North Sea at the time. In recent years, there has been a relative hiatus in gas plant investments, in part due to the availability of cheap coal imports from the USA. However, since liberalisation, investment in CCGT capacity has

significantly outpaced all other forms of generation. While CCGT is a lower carbon option than coal, it is generally accepted that if the UK is to meet its climate and renewable objectives, by the 2030s, unabated CCGT can only be used to provide flexible peaking plant at times of low wind (CCC, 2010).

This raises challenges for the financing of investment in new gas generation, which intersect with those for financing new renewable, nuclear and CCS generation. In the current situation, gas generators are able to hedge a significant degree of fuel price risk, as fluctuations in the costs of gas can be passed on to final customers. This is not the case for higher capital cost low carbon generators, whose costs are more associated with the one off initial capital investments rather than ongoing fuel costs; they therefore require a greater degree of certainty over long-term electricity prices to make an adequate return (for a more detailed discussion, see Gross et al., 2007). Investors are therefore more exposed to the risk of changes in wholesale electricity prices in the future. At the same time, gas generators often derive a significant proportion of their revenue from providing capacity during periods of peak load, or when intermittent wind or solar are scarce (Gross et al., 2010), (Carstairs and Pope, 2011; Zachmann, 2007). This controllable peaking plant, particularly gas, is currently key to balancing systems with high degrees of intermittent generation (Heide et al., 2011; Rasmussen et al., 2012). However, during periods when renewable generation becomes cheap at the margin, e.g. at times of high wind, renewables are increasingly replacing gas 'peaking plant', which may make it uneconomic for investors to invest in new gas generation assets, thus endangering security of supply (Channell et al., 2013; Redpoint, 2010).

A key motivation behind the UK government's EMR, introduced as part of the 2013 Energy Act, has been to address these new complexities and uncertainties, in order to give investors confidence in the returns they will realise from investment in both low carbon (renewables, CCS and nuclear), and peaking/balancing assets (primarily gas) (DECC, 2012; Redpoint, 2010). The central elements of EMR are contracts for difference (CfD) feed-in tariffs, supporting low carbon investment, and a capacity market, aiming to ensure security of supply.⁴ The capacity market works by giving selected capacity providers (e.g. generators, storage or demand side management) a steady payment to ensure enough capacity is in place to meet demand at peak periods (DECC, 2013). These payments are additional to those which generators can secure in the wholesale market and therefore place a premium on controllable generation, in theory incentivising investment in new CCGT peaking plant. The CfD feed-in tariffs support new low carbon generation by offering a fixed 'strike price', which differs for low carbon generation technologies. This consistent strike price, contracted for at least 15 years, is compared to the average annual wholesale price set by the market (a fluctuating reference price). Low carbon generators who have entered into a contract will receive the market price for their electricity plus a top up – the difference between the strike price and the market price – and in theory will have more certainty over long-term electricity prices. This should therefore stimulate greater investment in all forms of new low carbon generation, though, arguably, the design of CfD scheme was significantly influenced by the UK government's desire to create a support mechanism for new nuclear power, as well as for new large-scale renewable generation.⁵ The background to the introduction of the CfD market device was a critique of the previous renewables certificate trading scheme called the renewables obligation (RO).⁶ This model was criticised on the basis that it created additional risks in the market as oppose to a German style fixed feed in tariff scheme which offers a consistent price for a fixed period and is decoupled from the market (Mitchell et al., 2006; Woodman and Mitchell, 2011).

These EMR mechanisms are controversial in relation to their implications for technology outcomes and governance processes. For example, a contentious aspect of the new capacity

market is that payments may extend the economic life of fossil fuel generators, particularly coal and gas plant that may otherwise be shut down. A number of critical assessments have been made of this on that basis that incumbent technologies will benefit as the majority of the payments will go to existing coal, gas and nuclear plants,⁷ with a relatively minor proportion in terms of capacity going to more innovative solutions such as storage (6%) and demand side response (1%) (Evans, 2015; Mitchell, 2014). Also, in relation to CfD contracts, the move away from market led investment and towards long-term contracts has been questioned by some. For example Bunn and Yusupov (2015), based on modelling, suggest that as increasing amounts of renewables compete for market share, the certainty provided under the RO scheme in terms of output may outweigh the benefits of CfDs in terms of mitigating market price risk. Another issue that has been raised has been long-term uncertainty about the pool of money allocated to pay for the CfDs. This is to be paid out of a levy on customer bills – the levy control framework (LCF) – which goes to pay for a range of environmental policies, primarily support for renewables and now other low carbon technologies. In 2011, the government put a cap on the amount customers contribute to this levy up to 2020. Some, in particular the offshore wind industry, have criticised the LCF as it may limit the amount of new low carbon generation that can be supported in this period, and, as the government has not provided clear indications of the level of support available further into the 2020s when much of the renewable investment to decarbonise electricity is likely to take place, there is a degree of uncertainty about the medium and long-term integrity of the framework itself in the 2020s.

From a more macro perspective, some commentators lament the dismantling of the UK's liberalised electricity market model (Keay, 2012; Pollitt and Haney, 2013) which has been viewed as an exemplar for the move towards the liberalisation of infrastructure sectors internationally (Thomas, 2006). The following excerpts from two separate interviews illustrate the fault-lines of contemporary debate around the future of liberalised energy markets in the UK. The first (quote 1), from an employee in the commercial division of a large UK energy company, illustrates what might be termed as a conventional critique based on neo-classical economic theory of what is viewed as government interference in the price setting process. The second (quote 2), from an individual working in an investment management and advisory firm, outlines an alternative perspective; here government intervention is viewed as an inevitable consequence of the need for large scale investment to meet climate change targets.

Quote 1: If there really is a security of supply question it would be solved by the prices going up so that you then have the incentives to invest. Actually it kind of links in with the environmental one. [If] there really is an environmental issue and you tax the environmental damage the prices will go up to pay for the investment. (Interview 13)

Quote 2: Let's be clear, what's happening now under EMR is a substantial renationalisation of the investment making process in the energy sector. And that's alright in my view, that's kind of alright, I don't mind that. We have been big fans of the country having a plan. We think this picking winners argument is just ridiculous. If you want to achieve something in a certain timeframe and it's clear where the resource is, it's clear what are the technologies that can be deployed at scale. . . And this goes on to your question I suppose of the role of markets and different things. Yes markets with their short termism and their incentives and their focus on cost efficiency when you've got an infrastructure you're trying to sweat. But when you're trying to build a whole new one that's gonna cost you more than the one you have in the first place, then you can't expect the market to deliver all those investments. Hence in the UK the EMR. (Interview 5)

As these quotes suggest, concerns about investment uncertainty have moved to the core of contemporary energy governance in the UK. Both CfDs and capacity payments constitute

state intervention in the functioning of the electricity market, with the intention of reducing price uncertainty and delivering more predictable returns. In Knightian terms, this means moving from price uncertainty to calculable price risk. A move away from markets towards some form long-term contractual arrangement ensuring greater price certainty is perhaps unsurprising. As noted, institutional economists emphasise how economic actors seek to reduce uncertainty through such measures (Coase, 1937; Williamson, 1985), highlighting a continuum between the ideal type governance modes of markets and hierarchy, with various forms of hybrid modes of economic organisation in between.

Who will invest? Managing risks and engaging with institutional investors

Aside from debates about how best to reconfigure electricity markets, there is a concern about the capacity of the electricity supply industry, namely utility companies, to deliver the levels of investment required, which UK government estimates in the region of 110 bn in low carbon electricity generation, transmission and distribution infrastructure by 2020 (DECC, 2012). At the same time, the financial crisis has placed pressure on the balance sheets of the banks and utilities who have historically financed electricity investments. A new group of investors is being looked towards to deliver the significant upfront capital required for the decarbonisation of the UK's electricity sector, primarily institutional investors such as pension funds and insurance companies who manage large pools of capital (Nelson and Pierpont, 2013). However, these investments are perceived as risky by institutional investors who are unsure about long-term government commitments to the low carbon agenda (EY, 2014). A new energy policy discourse has emerged around the need for a more consistent, long-term energy and climate policy framework which takes into account the different types of risks these investors face and has measures in place to manage them – sometimes referred to as 'investment grade policy' (Sullivan, 2011).

These actors have historically been important investors in the energy sectors, but more indirectly as equity owners of corporate utilities. Their potential repositioning as more direct investors in projects has been forwarded as a means of bridging the 'financing gap'. Unlike specialist energy utilities, however, institutional investors have less specialist knowledge of electricity markets and technologies and are more risk averse. Government is therefore being called upon to reallocate risks and roles within the electricity regime.

Two institutional developments at the UK government level are spearheading this effort: The first is IUK, a unit within the Treasury 'made up of civil servants and private sector commercial experts' which '...works on the UK's long-term infrastructure priorities and secures private sector investment'.⁸ IUK develops annual National Infrastructure Plans which set priorities for the different economic infrastructure sectors (communications, transport, waste, water and energy), identifies key infrastructure projects and monitors their progress, and actively engages and communicates with the investment community through dedicated investor platforms. The second is the GIB, an initiative sponsored by the Department of Business Innovation and Skills whose purpose is to address a perceived 'market failure' (Wigley et al., 2010) in the financing of green infrastructure following the financial crisis of 2007/2008. This crisis adversely affected the willingness of banks to provide long-term debt for infrastructure investment, thus undermining the established project finance models, particularly for non-utility financed renewable generation (interview 12). The GIB was initiated in 2012 with £3.8 billion of government funding for investment 'in innovative, environmentally-friendly areas for which there is currently a lack of sufficient support from private markets' (Infrastructure UK, 2013: 86).

These initiatives are sponsored by different government departments and thus have distinct functions, for example, IUK looks across the energy, communications, water and transport sectors and is focused on near term objectives, i.e. accelerating economic growth and job creation, whereas the GIB has a remit to contribute to the long-term decarbonisation objective and prioritises specific energy/environmental investments (offshore wind, energy efficiency and waste). However, they share in common an ambition to improve the investability of low carbon technologies in the eyes of the investment community.

IUK has created pensions and insurance industry platforms that are emblematic of this wider UK government effort. The ‘Pensions Infrastructure Platform’ (PIP), for example, ‘has a 10 year target of raising an additional £20 billion infrastructure investment’ (Rhodes, 2013). A number of significant representative bodies of this industry (e.g. National Association of Pension Funds and Pension Protection Fund) have signed a memorandum of understanding with the UK government to work towards achieving the 10 year target. IUK noted in its 2013 Infrastructure Plan that ‘the PIP announced it had raised its first £1 billion of committed funds from 10 founding investors’ (Infrastructure UK, 2013: 88). IUK has setup a similar platform for the insurance industry: the insurers’ Infrastructure Investment Forum aims ‘to give members of the Association of British Insurers (ABI) a direct communication link to government’ (p. 88).

Building relationships with key actors in the investment community is an increasingly important objective for some government departments. In the quotation below from the head of investor relations in a governmental agency, the interviewee stressed how energy policy makers and regulators now specifically incorporate the views of city investors in policy formulation and are extremely keen to maintain an open dialogue with them.

Our investor relations role as any investor relations role in a company is a basically a two way communications with the investment community. By the investment community I mean analysts in the buy side, so that’s the brokers and the investment managers, investors themselves - the fund managers, portfolio managers, the investment bankers as well, investors in private equity, credit rating agencies, across the board of what is called the city really [...]. We read what is published, we listen to them, what they say, we attend companies presentations, when they do presentations for analysts, we attend them ourselves, and pick up on what kinds of questions that analysts are asking, what responses the companies are giving, we get a feel for what is happening. (Interview 14)

The interviewee went on to describe how, in these relations between government and investors, perceptions of uncertainty is a key concern:

...the problem with these things is that it only takes a couple of people [to] suddenly publish something quite negative about our policies, and they’re saying huge uncertainties... I think it is understanding how the city works, understanding how investors work, understanding the decisions that you make how they are going to affect people and how you say things and what you don’t say as well. It’s understanding that and also the level of uncertainty that you put out there for example when you leave something open. (Interview 14)

If institutional investors are to play a more significant role in financing the low carbon transition, a key challenge for energy policy is to understand how these actors view the world differently from more traditional investors. The traditional utility-based energy finance model was underpinned by specialised knowledge of energy technologies and long-term ownership and operation of assets. Institutional investors, on the other hand, prefer delocalised, highly tradable or liquid financial instruments and do not see their role as long-

term infrastructure owners/operators (Webb, 2014). These actors categorise infrastructure as one of a number of ‘asset classes’, the others being equities (shares in listed companies), private equity (investments in smaller non-listed companies), real estate and securities (government and company bonds) (UBS, 2011). Investors aim to become diversified across asset classes and allocate a specific percentage of their capital to each, depending on their attitude to risk. Infrastructure is viewed as relatively low risk, one interviewee noted that maturing pension funds are particularly attracted towards infrastructure investments where returns are predictable and preferably inflation linked (interview 12).

In the quotes below from an investment advisor it was outlined how these investors view infrastructure as a general class and are concerned with the risk/return ratio from energy projects relative to other investable infrastructure propositions as part of a global choice set:

We don’t need to invest in infrastructure at all or we can invest in hospitals and schools rather than wind turbines. We have pretty wide global choices about where we make our investments and we’ll chase the investments that’ll make the best returns for our customers, and so it really is a competitive market out there for capital and if the UK is a very confusing uncertain place where the governing coalition seems to have rather divergent views about the future of energy policy and there’s questions about commitment to the direction of travel. (Interview 5)

Due to the relatively recent history of infrastructure privatisation in the UK and elsewhere infrastructure is viewed as an ‘immature asset class unlike real estate or private equity and therefore the establishment of long term trends in terms of what’s an appropriate return for the risk is not particularly well established’ (Interview 6). Low carbon, particularly renewable electricity generation, as a specific subset of infrastructure, is itself even more immature and even more reliant on government policy in the form of market support mechanisms and subsidies. In the words of an investment advisor: ‘If you compare low carbon infrastructure to other kinds of infrastructure like hospitals or schools...I think there is a perception of greater policy risk’ (Interview 1).

Building trust between government and market actors is viewed as a central role of IUK and GIB. A core function of GIB, for example, is not only to directly invest in projects themselves, but to use its initial capitalisation to ‘catalyse private sector investment’ (Kingsbury, CEO).⁹ It aims to instigate a secondary market where ‘de-risked’ operational assets are sold on to institutional investors. One interviewee from an investment fund described it as getting ‘a bunch of projects that are already built, there are predictable flows of revenues... and then issue a bond to finance their ongoing growth’ (interview 1). A number of interviewees (1, 4, 5, 6, 8, 9, 12, 15) highlighted the need to establish a ‘pipeline’ of such investments to build confidence amongst investors. The role of government agencies such as the GIB in doing so was highlighted by the following interviewee:

...if the government comes along, [...]and provides some kind of guarantee around the construction risk...there are other ways potentially to provide the guarantees, then you have an investment grade BBB type bond which we could invest [in] potentially, a billion, two billion. (Interview 1)

One illustration of the intermediary role that GIB is playing in the creation of such a market is an initial investment made by government in Greencoat UK Wind, a company which consists of operational wind farms initially constructed by a number of large utility companies. Advised by the GIB, the UK government purchased £50m worth of shares in Greencoat when it was placed as an initial public offering on the London Stock Exchange in 2013. Greencoat and similar initiatives¹⁰ illustrate what many actors view as a potential new alignment of actors in the electricity regime; specialist energy companies with specific

expertise in large scale project development take a lead in constructing the plant, e.g. an offshore windfarm, and once it is operational and many of the early stage risks which institutional investors are unwilling to take on are overcome, it is refinanced. This form of capital recycling, in theory, frees up the balance sheets of utilities to finance further new investments, particularly those utilities which had expanded their asset portfolio prior to the financial crisis through debt financing. An interviewee from one of the UK's large utility companies however expressed nervousness about moving away from the traditional business and financing model:

In the past the reward has been running that station for the next 20-30 years. So you'd have to be able to get credibility about those returns to take it off your balance sheet by farming it off to someone. . . We in the energy industry are used to working with that and for twenty years at least it was reasonably stable. I'm not quite sure [where] it is at the moment or where it is headed. That worries us and it's probably going to worry external people even more [referring to shareholders in these companies]. That's my nervousness at being able to do that. (Interview 13)

IUK and GIB are institutional manifestations of a redefinition of government's role in relation to infrastructure investment in key economic sectors and low carbon technologies (Helm, 2013). Elements of investment risk are to be transferred from the private sector to energy customers and/or taxpayers, reducing the cost of capital for investors. That this reduces the overall economic cost to society of an energy transition is cited as a justification for this transfer of risk.

Discussion and conclusions

This paper began by outlining the relationship between electricity system governance and investment in capital intensive infrastructure. Throughout the history of modern infrastructure systems the creation of long-term certainty to enable investment in power plants, transmission lines, etc. has been an important aim of policies and institutions in the electricity sector, and similar infrastructure sectors such as water supply and public transport. In recent decades in many industrialised countries such as the UK the dominant organising principle for these systems has been market led, with the underpinning assumption that private investors operating on the basis of price signals with minimal government intervention would lead to 'optimal' investment decisions. However, in the context of climate change new uncertainties about the future trajectory of electricity system change is prompting institutional responses to the challenge of creating investment certainty.

The market-based electricity regime which emerged following liberalisation reforms in the UK had been configured for investment in fossil fuel based generation. However because of the distinct materiality of low carbon technologies (more capital intensive, relatively immature and low marginal costs) and the financial crisis, the established approach of financing investments from bank debt and corporate utility balance sheets has been undermined (Hall et al., in press; Hall et al., (2015)). Reforms to the electricity market, new policy supports and investment vehicles are being introduced with the aim of channelling new sources of finance from institutional investors into the electricity sector. We are seeing the potential repositioning of actors within the electricity regime where utilities transfer de-risked operational assets to institutional investors who play a more direct role in terms of finance and ownership, with government playing a key facilitating role.

Through the lens of transitions theory, these empirical findings can be seen as a response of the incumbent socio-technical 'regime' to new uncertainties. The study thus contributes to

an understanding of the real world practices of governing sustainability transitions and feeds into an emerging topic in the literature about incumbent regime agency. Our analysis of UK electricity indicates that regime responses are not monolithic and pre-determined. For example, we observed some reluctance on the part of utility companies who currently operate much of the asset base to participate in the proposed recalibrated electricity regime. Also, the process of market reforms and institutional change may itself be a source of additional risks and uncertainties as policy changes create new complexities. The politicisation of electricity investment may turn out to be a new source of uncertainty as the process is increasingly dependent on the long-term commitment of government to the decarbonisation agenda, which may be undermined as other priorities (energy security and cost) become more salient.

The analysis also illustrates how certain regime actors frame the low carbon transition primarily in technological terms with institutional changes seen as necessary to facilitate investment in large scale infrastructure projects. This means that shared regime assumptions, such as a focus on increasing electricity supply rather than reducing demand, and stimulating private sector investment as the main vehicle to achieve this, hold sway.

Through our analysis we have observed how the interests of certain actors (particularly private investors) are becoming inscribed into the market structures and regulatory frameworks which allocate investment risks and returns. It may be the case that these processes will accelerate low carbon investment and enable the UK to achieve its emission targets, alternatively they may serve to lock-out alternative pathways of change such as demand reduction through lifestyle change or more decentralised system configurations based on civic or community ownership (Hall et al., in press). Placing the analytical focus on investment and incumbent regimes helps to uncover underlying issues shaping the politics of energy transitions, for example; the distribution of investment risks and returns of long-term capital investments, how institutions mediate the balance between private returns and wider societal benefits from investments, and how market and regulatory reforms limit or enable participation in socio-technical change.

Acknowledgements

We are grateful to the interviewees, who have been generous with their time and insights. We would like to thank Dr Antti Silvast and Dr Dave Hawkey for their helpful comments on an earlier version. The usual disclaimers apply.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The research was funded by the UK Engineering and Physical Science Research Council (EPSRC) as part of the RealisingTransition Pathways consortium (EPSRC Reference: EP/K005316/1).

Notes

1. There is a wider sociology literature on risk governance not discussed here. See e.g. (Beck, 1992; O'Malley, 2005).

2. British Electricity Trading and Transmission Arrangements.
3. On average 2.1 GW of CCGT was added to the system annually during the 1991–2000 period (Kern, 2012).
4. The third policy instrument is an Emissions Performance Standard (EPS) which sets a limit of 450 g/kWh for all new fossil fuel plant with the purpose of ensuring that there will be no more unabated coal plants built in the UK. Also, due to the poor performance of the European Emissions Trading Scheme, as part of the overall policy package, the UK Treasury will introduce an artificial floor on the carbon price for electricity generation. As part of the 2011 Finance Act, a carbon price floor is to be introduced in 2013 at approx £15.70/tCO₂, rising to £30/tCO₂ in 2020 and £70/tCO₂ in 2030. The automatic rise in this carbon floor price was put on hold in the Government's 2014 Budget.
5. At the time of writing, the support for the first new nuclear power station to be built at Hinkley Point C was the subject of a legal challenge by the Austrian government, under EU state aid rules.
6. 'Britain introduced its green certificate mechanism, the Renewable Obligation Certificates (ROCs), in 2002, the market prices of which were determined by the demand and supply of renewable energy in the wholesale market on an annual basis. Demand was created by an obligation on retail suppliers to cover a specified fraction, increasing yearly, of their sales with certified green energy; supply was provided by metered renewable generation (with an administered buy-out supply to meet any shortfalls)' (Bunn and Yusupov, 2015).
7. Gas plants – 45%; coal or biomass plants – 19%; nuclear – 16% (Evans, 2015).
8. <https://www.gov.uk/government/organisations/infrastructure-uk/about>
9. <http://www.publications.parliament.uk/pa/cm201314/cmselect/cmenvaud/191/130912.htm>
10. For more examples, see: <http://www.greeninvestmentbank.com/our-investments/>

References

- Beck U (1992) *Risk Society: Towards a New Modernity*. Sage.
- Beckert J (1996) What is sociological about economic sociology? Uncertainty and the embeddedness of economic action. *Theory and Society* 25: 803–840.
- Bolton R and Foxon T (2013) Urban infrastructure dynamics: Market regulation and the shaping of district energy in UK cities. *Environment and Planning A* 45: 2194–2211.
- Bolton R and Foxon TJ (2015) A socio-technical perspective on low carbon investment challenges – Insights for UK energy policy. *Environmental Innovation and Societal Transitions* 41: 165–181.
- Boston A (2013) Delivering a secure electricity supply on a low carbon pathway. *Energy Policy* 52: 55–59.
- Bunn D and Yusupov T (2015) The progressive inefficiency of replacing renewable obligation certificates with contracts-for-differences in the UK electricity market. *Energy Policy* 82: 298–309.
- Carstairs J and Pope I (2011) The case for a new capacity mechanism in the UK electricity market—Lessons from Australia and New Zealand. *Energy Policy* 39: 5096–5098.
- Channell J, Jansen HR, Syme AR, et al. (2013) *Energy Darwinism: The Evolution of the Energy Industry*. New York, NY: Citi Research.
- Chick M (2008) *Electricity and Energy Policy in Britain, France and the United States since 1945*. Cheltenham, Edward Elgar.
- Coase R (1937) The nature of the firm. *Economica* 4: 386–405.
- Committee on Climate Change (CCC) (2010) *The Fourth Carbon Budget Reducing Emissions Through the 2020s*. London: Committee on Climate Change.
- Department of Energy and Climate Change (DECC) (2012) *Electricity Market Reform: Policy Overview*. London: Department of Energy and Climate Change.
- DECC (2013) *Electricity Market Reform: Capacity Market – Detailed Design Proposals*. London: Department of Energy and Climate Change.
- Evans S (2015) Old coal and gas plants won largest share of capacity market, final results confirm. The carbon brief. Available at: www.carbonbrief.org/blog/2015/01/old-coal-and-gas-plants-won-largest-share-of-capacity-market-final-results-confirm/ (accessed 15 November 2015).

- EY (2014) *Renewable Energy Country Attractiveness Index. Issue 42*. London: Ernst & Young.
- Fligstein N (2001) *The Architecture of Markets: An Economic Sociology of Twenty-First-Century Capitalist Societies*. Princeton, NJ: Princeton University Press.
- Geels FW (2002) Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy* 31: 1257–1274.
- Geels FW (2011) The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions* 1: 24–40.
- Geels FW (2014) Regime resistance against low-carbon transitions: Introducing politics and power into the multi-level perspective. *Theory, Culture & Society* 31(5): 21–40.
- Granovetter M and McGuire P (1998) The making of an industry: Electricity in the United States. In: Callon M (ed.) *Laws of the Markets*. Oxford: Wiley-Blackwell, pp. 147–174.
- Gross R, Blyth W and Heptonstall P (2007) *Investment in Electricity Generation: The Role of Costs, Incentives and Risks*. London: Imperial College.
- Gross R, Blyth W and Heptonstall P (2010) Risks, revenues and investment in electricity generation: Why policy needs to look beyond costs. *Energy Economics* 32: 796–804.
- Hall S, et al. (in press) Financing the Civic Energy Sector: How financial institutions affect ownership models in Germany and the United Kingdom. *Energy Research & Social Science*.
- Hall S, et al. (in press). Financing the Civic Energy Sector: How financial institutions affect ownership models in Germany and the United Kingdom. *Energy Research & Social Science*.
- Hamilton K (2009) Unlocking finance for clean energy: The need for ‘investment grade’ policy. Chatham house briefing paper EERG BP 2009/06.
- Heide D, Greiner M, von Bremen L, et al. (2011) Reduced storage and balancing needs in a fully renewable European power system with excess wind and solar power generation. *Renewable Energy* 36: 2515–2523.
- Helm D (2003) *Energy, the State, and the Market: British Energy Policy Since 1979*. Oxford: Oxford University Press.
- Helm D (2013) British infrastructure policy and the gradual return of the state. *Oxford Review of Economic Policy* 29: 287–306.
- Hoogma R, Kemp R, Schot J, et al. (2002) *Experimenting for Sustainable Transport: The Approach of Strategic Niche Management*. London: Spoon Press.
- Hughes T (1983) *Networks of Power: Electrification in Western Society, 1880–1930*. Baltimore: Johns Hopkins University Press.
- Infrastructure UK (2013) *National Infrastructure Plan 2013*. Part of UK Government Autumn Statement 2013. London: UK Treasury.
- Karltorp K and Sandén BA (2012) Explaining regime destabilisation in the pulp and paper industry. *Environmental Innovation and Societal Transitions* 2: 66–81.
- Key M (2012) *Death by a Thousand Regulations: The New Energy Bill*. Oxford: Oxford Institute for Energy Studies.
- Kemp R, Schot J and Hoogma R (1998) Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis & Strategic Management* 10: 175–198.
- Kern F (2012) The development of the CCGT and the ‘dash for gas’ in the UK power industry (1987–2000). *Final case study report as part of work package 2 of the UKERC project: ‘CCS – Realising the potential?’*. London: UK Energy Research Centre.
- Knight FH (1921) *Risk, Uncertainty and Profit*. Boston and New York: Kelley.
- Meadowcroft J (2009) What about the politics? Sustainable development, transition management, and long term energy transitions. *Policy Sciences* 42: 323–340.
- Mitchell C (2008) *The Political Economy of Sustainable Energy*. New York: Palgrave Macmillan.
- Mitchell C (2014) Britain’s dinosaur capacity market will worsen energy ‘trilemma’. IGov, University of Exeter. Available at: <http://projects.exeter.ac.uk/igov/britains-dinosaur-capacity-market-will-worsen-energy-trilemma/> (accessed 15 November 2015).

- Mitchell C, Bauknecht D and Connor PM (2006) Effectiveness through risk reduction: A comparison of the renewable obligation in England and Wales and the feed-in system in Germany. *Energy Policy* 34: 297–305.
- Nelson D and Pierpont B (2013) *The Challenge of Institutional Investment in Renewable Energy*. San Francisco: Climate Policy Initiative.
- O'Malley P (ed.) (2005) *Governing Risks*. Aldershot: Ashgate.
- Ottosson M and Magnusson T (2013) Socio-technical regimes and heterogeneous capabilities: The Swedish pulp and paper industry's response to energy policies. *Technology Analysis & Strategic Management* 25: 355–368.
- Pollitt MG and Haney AB (2013) Dismantling a competitive electricity sector: The U.K.'s electricity market reform. *The Electricity Journal* 26: 8–15.
- PricewaterhouseCoopers (PWC) (2010) *Meeting the 2020 Renewable Energy Targets: Filling the Offshore Wind Financing Gap*. London: PricewaterhouseCoopers.
- Rasmussen MG, Andresen GB and Greiner M (2012) Storage and balancing synergies in a fully or highly renewable pan-European power system. *Energy Policy* 51: 642–651.
- Redpoint (2010) Electricity market reform, analysis of policy options. Redpoint in association with Trilemma.
- Rhodes C (2013) *Infrastructure Policy*. London: House of Commons Library.
- Smink MM, Hekkert MP and Negro SO (2015) Keeping sustainable innovation on a leash? Exploring incumbents' institutional strategies. *Business Strategy and the Environment* 24: 86–101.
- Smith A, Stirling A and Berkhout F (2005) The governance of sustainable socio-technical transitions. *Research Policy* 34: 1491–1510.
- Stenzel T and Frenzel A (2008) Regulating technological change: The strategic reactions of utility companies towards subsidy policies in the German, Spanish and UK electricity markets. *Energy Policy* 36: 2645–2657.
- Steward F (2012) Transformative innovation policy to meet the challenge of climate change: Sociotechnical networks aligned with consumption and end-use as new transition arenas for a low-carbon society or green economy. *Technology Analysis & Strategic Management* 24: 331–343.
- Sullivan R (2011) *Investment-grade climate change policy: Financing the transition to the low-carbon economy*. Report for Institutional Investors Group on Climate Change (IIGCC), the Investor Network on Climate Risk (INCR), the Investor Group on Climate Change Australia/New Zealand (IGCC) and the United Nations Environment Programme Finance Initiative (UNEP FI).
- Thomas S (2006) The grin of the Cheshire cat. *Energy Policy* 34: 1974–1983.
- Turnheim B and Geels F (2013) The destabilisation of existing regimes: Confronting a multi-dimensional framework with a case study of the British coal industry (1913–1967). *Research Policy* 42: 1749–1767.
- UBS (2011) *An Introduction to Infrastructure as an Asset Class*. New York: UBS Global Asset Management.
- Unruh GC (2000) Understanding carbon lock-in. *Energy Policy* 28: 817–830.
- Waissbein O, Glemarec Y, Bayraktar H, et al. (2013) *Derisking Renewable Energy Investment: A Framework to Support Policymakers in Selecting Public Instruments to Promote Renewable Energy Investment in Developing Countries*. New York: United Nations Development Programme.
- Webb J (2014) Evaluating urban energy systems in the UK: The implications for financing heat networks. *Science and Technology Studies* 27: 47–67.
- Wigley B, Cameron J, Ferguson M, et al. (2010) Unlocking investment to deliver Britain's low carbon future. Report by the Green Investment Bank Commission.
- Williamson O (1985) *The Economic Institutions of Capitalism*. New York: Free Press.
- Winkel M (2002) When systems are overthrown: The 'dash for gas' in the British electricity supply industry. *Social Studies of Science* 32: 563–598.
- Winkel M and Radcliffe J (2014) The rise of accelerated energy innovation and its implications for sustainable innovation studies: A UK perspective. *Science and Technology Studies* 27: 8–33.

- Woodman B and Mitchell C (2011) Learning from experience? The development of the renewables obligation in England and Wales 2002–2010. *Energy Policy* 39: 3914–3921.
- Zachmann G (2007) A Markov switching model of the merit order to compare British and German price formation. Discussion papers, German Institute for Economic Research.

Ronan Bolton is Lecturer in Science, Technology and Innovation Studies at the University of Edinburgh. His work examines the interconnected policy, market and regulatory challenges of transforming carbon based energy systems and enabling the development of lower carbon energy infrastructure.

Timothy J Foxon is Professor of Sustainability Transitions (SPRU – Science Policy Research Unit, The Sussex Energy Group). He is a leading expert of innovation systems and processes for a transition to a low carbon economy.

Stephen Hall is a postdoctoral research fellow in low-carbon energy futures at the Sustainability Research Institute, University of Leeds. His research is focuses on the technological, financial and governance challenges of transitioning to sustainable energy systems.

Appendix – list of interviews

- (1) Head of sustainability at a large investment fund. 14 January 2013
- (2) Head of renewables policy at a major UK energy utility. 15 January 2013
- (3) Company secretary of an energy cooperative. 25 January 2013
- (4) Managing director of energy innovation at a major UK energy utility. 24 January 2013
- (5) Head of advisory at a specialist environmental investment group. 4 February 2013
- (6) Partner at an advisory firm specialising in private equity and infrastructure investments. 4 February 2013
- (7) Co-founder and director of an investment company specialising in small scale renewables. 5 February 2013
- (8) Partner and head of sustainability research at an investment group specialising in sustainability. 6 February 2013
- (9) Investment director at a European investment fund specialising in energy, climate change and infrastructure. 25 February 2013
- (10) Individual renewable energy project developer. 28 February 2013
- (11) CEO of a NGO which campaigns for sustainable investment practices in the pensions sector. 6 February 2013
- (12) CEO of an investment industry professional body promoting sustainable investment practices. 4 April 2013
- (13) Senior member of the commercial department of a major UK energy utility. 5 April 2013
- (14) Employee in the investor relations team of an energy related government agency. 14 June 2013
- (15) Senior civil servant working on renewable deployment. 9 August 2013