Exploring the Politics of Low Carbon Energy Transition

ECPR Annual Conference, Sciences Po, Bordeaux, September 2013

By
Dr Caroline Kuzemko
Research Fellow
Energy Policy Group
University of Exeter

DRAFT: PLEASE DO NOT CITE WITOUT AUTHOR'S PERMISSION

Introduction

Profound structural change is an area of active and current debate within the political sciences. A variety of different conceptualisations of how and why change as a process occurs have been offered, albeit usually constructed with the benefit of hindsight. We are currently, however, living within a period of profound crises within, and changes and challenges to, existing political institutions. There are a range of current crises ongoing, economic, financial, hegemonic, welfare and environmental, but this paper is concerned in particular with the growing political recognition of anthropogenic climate change and of the need to act to mitigate its effects. Since the first United Nations Conference on the Human Environment in 1972 environmental questions about climate change, and policies to address these issues, have been debated. At the international level what has resulted in terms of agreement has been limited largely to an agenda of target setting around the agreed 2˚C limit to global temperatures from pre-industrial levels. Given the close relationship between energy use and climate change emissions transition to a low carbon energy system is widely understood to form a central part of the solution to climate change. This paper provides both specific and contingent explanations of the politics of low carbon energy transition from the starting point that, despite varying degrees of political debate and activity in this area, fossil fuels still provide 87% of global energy consumption and are predicted to dominate significantly for decades to come (IEA 2012).

Explanations of the politics of low carbon transition are provided here by conceptualising energy systems as being made up of interactions between a variety of social and material factors (cf. Lovell et al 2009) and by applying concepts from two broad disciplinary areas, socio-technical transitions (STT) and sociological institutionalism. These concepts have been chosen in that they do much to explain processes of profound change and in that both have evolved using insights from multiple conceptual disciplines. The paper marks, as such, one attempt to move beyond the application of single paradigms for analysing problems in our complex world (Katzenstein 2009). STT formulates understandings of transitions based on the notion that energy systems are both social and technical in nature – specifically that firms, infrastructures and technologies are embedded within wider social and economic systems (Rip and Kemp 1998). A wide range of STT scholars highlight the unprecedented nature of, and the importance of politics to, low carbon transition. Despite these observations political aspects of energy system transitions have remained under explored (Kern 2011b; Meadowcroft 2005). There persists, therefore, a lack of consideration of the

complexities of energy politics and policy, of the multiple ways in which energy policy is contingent upon other political institutions and, indeed, of how and why policy changes.

This paper constructs a framework of analysis that can flesh out some of the complexities of energy policy for transition and explain the ways in which these have constrained, enabled and coloured energy system transition so far. It explains why setting climate targets, and including them as objectives of energy policy, has not produced the desired results. Insights from sociological institutionalism explain why energy policy is changing in certain ways, but not in others, thereby providing further insight into the *nature* of energy and climate policy change (Blyth 2002; Hall 1993; Hay 2002; Schmidt 2002). Energy policy is characterised here as containing elements that are contingent upon broader political ideas and institutions as well as aspects that are specific to the politics of energy within different socio-economic contexts.

By combining insights from these two broad conceptual approaches we can construct a framework that takes account of the complexity of energy and climate policy but that maintains the importance of other important actors and infrastructures within the process of low carbon transition. Climate policies may be pursued but these do not always result in significant change to other areas within energy systems. Technologies and infrastructures are emphasised, therefore, as important to understanding transition but on the understanding that, like policy, they need to be explained as social constructs developed within '…the context of particular structures of political economy' (Hayward 1998: 81; cf. Lovell and Liverman 2010). This approach in that it emphasises energy system transition as a means of limiting global warming, and following Newell and Paterson, accepts that climate change mitigation is proceeding within current socio-economic structures (2010: 6-8). Such acceptance comes partly because the urgent temporalities of climate change do not allow for nothing to happen now and no revolutionary alteration to the current international political economy is apparent. This approach does, however, allow that the nature of low carbon transition may well offer further challenges to current models of capitalism, some more than others, and may colour how capitalisms operate in practice.

1. Socio-technical Transitions Literatures

STT literatures collectively offer many important insights into low carbon energy system transition – often using historical analysis to inform current practices. What should be noted at this point is that transition has powerful normative attractions for those concerned with climate change mitigation and sustainability. Some STT scholars seek not only to understand systemic change for its own sake but also in order to enable certain futures:

> *(l)ow-carbon transitions… are 'purposive transitions', which are deliberately intended and pursued from the outset to reflect an explicit set of societal expectations or interests.* (Smith et al 2005: 1502)

Answers to questions about whether climate change is anthropogenic or not, or about whether we should be acting to secure a more sustainable future for our planet have already been reached – yes being the answer in both cases. In fact for many answers to these questions were supplied long ago within scientific communities but academics and other stakeholders have, since then, had to watch in growing dismay and disbelief whilst low carbon transition has been contested, painstaking and slow. Although the task of explaining change whilst it is ongoing is a challenging one, we do in this instance have some information at least about what the future should look like: it should be low carbon and sustainable.[i] But given the degree of uncertainty associated with periods of transition, and the variety of different political and technical pathways currently being contested, this is as much as we can know about the proposed new energy system.

STT concepts originally emerged out of a desire to explain how innovation and new technologies can stretch and redefine some of the natural resource limits, and their implications for humankind, outlined in the 1972 Club of Rome book 'Limits to Growth' (Smith et al 2010: 436). Broadly speaking this literature has been informed by "studies of science, technology and innovation" (Shove and Walker 2010: 471), environmental and evolutionary economics and by history and sociology of technology (Markard et al 2012: 957). Technology is understood as enabling not only clean and sustainable sources of energy, such as renewables, but as also capable of enabling all sorts of change in how energy is stored, transported and consumed.

1.1 *What is a Socio-technical System and How Does it Change?*

What STT offers, aside from insights into transitions, is a way of understanding technical systems as fulfilling important social needs as well as a way of linking together politics with technologies and infrastructures. Within the broad STT literature systems are understood as being made up of a wide range of analytically separable but dynamically inter-related areas - for example user practices, the environment, infrastructures, technology, corporate groups, civil society, institutions and politics (Foxon 2011: 2262; Rotmans et al 2001: 16). Each socio-technical system has its own complex configurations between these areas that together make up an entire system of consumption and production – thereby directly relating technological functions to the delivery of social needs and practices (Smith et al 2010: 436; Markard et al 2012: 956). Any given socio-technical system is, in addition, likely to actively inter-relate with and provide context for other socio-technical systems (Foxon 2011: 2262). For example fossil

fuel and transport systems have been intrinsically inter-linked historically and practices in each area have tended to both influence and support certain, carbon intensive, practices in the other. As such they can be understood, when taken together, as making up one broader area in which powerful path-dependencies have arisen that have so far impaired low carbon transition.

According to the multi-level perspective (MLP) socio-technical systems, or 'regimes', also interact across and between other levels, the 'sociotechnical landscape' (macro) and 'niche-innovations' (micro) – these levels are understood as heuristic, analytical concepts that help to explain both how systems operate and change (Geels and Schot 2007: 399). The regime, which constitutes mainstream ways of realising various social functions, sits between landscape and niche levels and provides the 'selection environment' for new technologies and other innovations (Smith et al 2010: 440). Regimes are made up, in addition to technologies and infrastructures, of shared cognitive routines that inform specific rule sets, cultures and skills that become embedded within institutions, political and/or corporate, over time. These rule sets can stabilise existing trajectories but also, importantly, blind actors to new developments outside their focus (Geels and Schot 2007: 400). The landscape level represents the 'external structural context' for the regime level and is made up of social and physical factors such as broad political coalitions, socio-cultural norms, paradigms, and economic growth (Geels and Schot 2007: 400; Smith et al 2010: 440). The niche level, as will be made more clear below, is highly significant in that this is where radical novelties, which can pioneer new ways of constituting and satisfying social demands, are understood to emerge (Kemp et al 1998; Geels and Schot 2007).

A socio-technical transition, as opposed to the somewhat path dependent account of regimes, is described as a large-scale transformation within society during which the structure of the societal system fundamentally changes (Verbong and Loorbach 2012: 6), often taking place over considerable periods of time. It is made up of sets of interconnected changes that reinforce each other but, as with conceptualisations of regimes, also take place across and between several different areas and levels (Rotmans et al 2001: 2). Low carbon transition, has been described as involving changes to:

> *...practices of energy use; innovation and deployment of a range of low carbon technologies; and a broader change in the mix of industries within national and global economies* (Foxon 2011: 2258)

These kinds of changes infer not only new production and consumption patterns but also that different social groups, for example new producers, distributors and retailers, will benefit from the process of transition while others lose out (Fouquet 2010: 6591). This is partly why some

incumbent groups can so often pitch their, often not inconsiderable, assets at resisting change or at least at influencing what kind of change takes place (ibid 2010: 6592).[ii]

In terms of thinking about why change actually takes place, niches are understood as exogenous sites of 'revolutionary change', in contrast to regimes that tend to reproduce normal innovation patterns (Smith 2010: 440). However it is often changes in the landscape level that tend to destabilise regimes thereby creating opportunities for niches to break through (Geels and Schot 2007: 400; Kern 2011b: 301; Smith et al 2005: 1496). A specific example of this might be that new scientific knowledge about climate change, considered as exogenous to the fossil fuel regime, is putting pressure on current regimes of energy production and consumption to change. This has in some countries allowed for new niches to break through, for example energy produced from renewable sources, and form part of an emerging but alternative regime of energy production and usage. In terms of understanding how change takes place, however, transitions concepts focus very much on factors exogenous to regimes to force change – ideas seem to locate themselves at all levels, but new ideas seem to be found at landscape or niche levels. This suggests that regimes are largely path dependent in nature without dynamic elements that might permit change.

1.2 *Low Carbon Energy Transition as Unprecedented*

So far we have been able to establish a picture of transition as fundamental change to path-dependent regimes that includes interactions between social factors, technologies and infrastructures. Below we outline three further insights that shed light on some of the peculiarities of low carbon transition that arguably mark it out from previous energy transitions and make it unprecedented.

1.2.1 *Temporality of Change*

Transitions are understood to represent a multiple of processes that take place over extended periods of time but also include different, but important, stages. One example is the 'innovation chain' whereby new technologies progress from initial innovation at the niche level, via development, learning and declining costs, before implementation and diffusion phases (Fouquet 2010: 6587). The work of economic historian Carlota Perez on technological revolutions also emphasises change through phases: development, finance and installation; transition including crisis; and mass roll out (Perez 2002). Perez's work, unlike many economic historians, emphasises the different roles played historically by market actors, often in the form of private financial institutions, and by state actors during different phases. She argues that state actors have tended to play a much greater role in the third, post crisis, phase in

order to underpin mass roll-out and deployment of new technologies such that benefits are distributed more widely in society (ibid 2002). One example of this might be the central role state actors took in establishing electricity transmission networks in many countries so that populations as a whole could benefit from access to affordable electricity and associated modernisations.

An emphasis on transition as phased helps to highlight one important aspect of socio-technical transitions – that historically they took place over considerable periods of time (Fouquet 2010; Grubb et al 2008; Jefferson 2008). Roger Fouquet's historical analysis of major transitions in UK energy services over the past 200 years notes that it took an average of over 100 years for new technologies and services to travel along the innovation chain, and then a further 50 years to diffuse (Fouquet 2010: 6592). This is because, as one example suggests, there are path dependencies slowing transition down:

> *… lock-in effects: lack of new knowledge and skills amongst sub-groups, slow 'innovation chains' amongst households meant that it took roughly 150 years for the switch from wood fuel to coal to take place in heating* (ibid 2010: 6588).

Clearly, different systems transitioned at different rates. It took centuries for the transition from traditional animate energy to fossil fuel sources to evolve, involving numerous services and sectors at different times between 1500 and 1920 (ibid: 6590). Despite noting that innovation chains appear to be becoming slightly shorter over time, this research concludes that *early* and decisive political action is warranted to steer transition to a low carbon economy and to support the development of new technologies (ibid 2010: 6596). This kind of role for political actors in supporting early development stages is not unprecedented, see for example US state support for information technology research and development (Crouch 2005), and the many instances of, now less popular, infant industry protection historically (Chang 2009). An emphasis on policy action now is all the more relevant within the context of temporally set emissions reduction targets and the need to keep warming to within 2°C of pre-industrial levels.

1.2.2 *Catalysts for Socio-Technical Systems Transition*

The second aspect of low carbon energy transition that makes it unprecedented relates to catalysts for change. It is worth returning here to historical accounts of sociotechnical transitions and asking more specific question about historical drivers of system transition (Fouquet 2010). It has been observed that principal drivers for structural change in energy were to do with prices, costs but also better services. Specifically it is noted that historically "… in all cases cheaper or better services were key to the switch" – better being defined as services that were easier, cleaner, safer or more flexible to use (ibid: 6591). This infers that

consumers of new energy services, industrial and individuals, experienced major, clearly tangible improvements. Taking electric light as an example, instead of having to fill potentially dangerous lamps with gas individuals were able to flick a switch on a wall for light thereby receiving a clearly discernable benefit. Although the high price of new innovations often made them accessible initially to a limited range of end users, enough consumers were willing, and able, to pay extra given the tangible differences experienced. Such support for new technologies during the phase of higher prices, before learning and economies of scale allowed for prices to fall, enabled many new innovations to become refined gradually until they could compete with the incumbent energy source (ibid: 6586).

Low carbon transition appears to have rather different drivers given that consumers this time around appear to perceive and value, for example, renewable sources of energy rather differently than previous energy innovations. This might not be surprising given that how people *experience* these innovations is indeed different. Consumers, who may or may not believe in anthropogenic climate change, are in effect being asked to pay more for services that they will experience in exactly the same way as before: a light switch turned on will still emit light, a mobile phone plugged into a socket will still be recharged. The benefits that accrue from low carbon energy are longer term and are not immediately visible or touchable – as such only a very few have so far been willing and able to pay more to enable wider, longer-term social benefits. Some analyses of low carbon transition conclude that without legislation it can be expected that most consumers will not pay more for the environmental improvements as the benefits are social rather than private (Fouquet 2010: 6593; Turnheim and Geels 2012: 36).

Given these observations about the ability of niche technologies to act as catalysts in low carbon transition other drivers of change become vital. As already observed low carbon transition, to the extent that it is taking place, has been driven by new scientific *knowledge* about anthropogenic climate change which finds political articulation in climate targets and attempts, thereby, to destabilise fossil fuel regimes. One analysis acknowledges that there are often multiple pressures on a regime to change but argues that only those that are articulated successfully and coherently can enable transition (Smith et al 2005: 1495). It is, therefore, not only the degree of consensus about the links between greenhouse gas emissions and anthropogenic climate change but also the process of articulating such knowledge politically that are essential to the realisation of transition.

1.2.3 *Energy Policy as Enabling Energy System Change*

Given that knowledge about carbon emissions is a significant catalyst for change the case for linking climate change and energy policy is clear – for example in 2011 an estimated 84

percent of total UK climate change emissions came from the energy supply sector (DECC 2012). Therefore policy designed to reform fossil fuel based energy production and consumption patterns, increase efficiencies and reduce demand can serve as a force for climate change mitigation. Politics has been described as the 'constant companion' of socio-technical transitions - it forms part of the landscape, regime and niche levels and it serves as context, enabler, obstacle, arbiter, distributor of benefits and manager of repercussions (Meadowcroft 2011: 71). Low carbon transition is intensely political given that it is a normative project built around particular visions of what the socio-technical future should look like and that it is driven towards wide ranging, long-term social benefits. At the same time, however, certain governance practices and decisions, as we will see in more detail below, have tended to obstruct whilst others have been more supportive of niche innovations and low carbon transition.

As such low carbon transition is understood as more directed than previous, more 'organic', socio-technical transitions (Scrase and Smith 2009: 709; see also Fouquet 2010). Debates in technology policy have shifted towards the conclusion that governance must be designed such that policies can catalyse fundamental, system-wide, low carbon change (Kern 2011a: 300; see also Meadowcroft 2005; van den Bergh et al 2007; Markard et al 2012). This conclusion ties in with scholars of the politics of climate change who also argue for a central role for governance within transition (Carter 2007; Mitchell 2008; Giddens 2009; Newell and Paterson 2010). Much of the work on governing for transition is focused on the all important niche markets that are vulnerable until the diffusion stage. What is therefore needed is a protected market within which niches have time to develop, to learn by doing and to enable technological refinements (Fouquet 2010: 6594). Given the current lack of willingness to pay higher prices for niche, low carbon products it is proposed that state and sub-state actors, and other international organisations, act to directly support technological innovation at the niche level.

Some scholars have observed that STT debates about the role of governance have tended to be too neutral and apolitical and partly out of this critique a new approach, Transitions Management (TM), has emerged. This approach has defined an instrumental, practice oriented model for the *kind* of governance that would be most appropriate in supporting niche innovations and low carbon transition (Markand et al 2012: 958). TM combines insights from STT with complex systems theory and governance approaches and has, interestingly, already been adopted in the Netherlands as part of its energy innovation policy (Meadowcroft 2005). This approach suggests that policy could be an enabler of change not just through directly supporting niche innovations, but also by becoming a site for learning and

knowledge and by supporting linkages between the niche and regime levels. Governments should take a leadership role by clearly articulating the scientific consensus about environmental pressures as well as providing long-term direction, conviction and plans (Smith et al 2005: 1496). Furthermore reflexive, co-operative, learning by trying and evolutionary governance processes would be required in order for low carbon transition to succeed (Voß et al 2006). These changes would need also to contribute towards energy transition taking place in a socially equitable way (Foxon 2011: 2258).

Such approaches to governing for change however attractive may appear somewhat unrelated to many current energy policy practices – a point to which we return below. It is, however, important to note the argument that the directed nature of low carbon energy transition marks it out not only as unprecedented but it also makes policy and politics central to transition. Despite a decade or so of climate change mitigation target setting at international, regional and national levels energy infrastructures based on fossil fuel technologies persist. Renewable energy is growing as a percentage of the global energy mix but still provides only 2% of energy consumption (IEA 2012).

2. Energy Transition Policy: Contingencies and Specificities

Although STT literatures identify a central role for policy in transitions and emphasise complex inter-dependencies between areas, energy policy is not analysed in any great depth. STT has, as such, been less adept at formulating understandings of the ways in which energy policy co-exists with other political institutions. Some analyses that do take policy into account have focused on proscribing what energy policy for transition could or should be rather than questioning the political circumstances that make the adoption of certain policies likely (Meadowcroft 2011: 73). TM literatures, for example, fail to explain that current political configurations need to give way to their visions of transition governance or indeed how this might happen. Directed transition can, as a result, come across as being quite straightforward in theory when the reality has, in many countries including the Netherlands where TM was taken up, been quite different (see Kern and Howlett 2009). As such although sociotechnical explanations allow for a constitutive role for interpretive frameworks, historically embedded norms and power structures more needs to be done to understand these constructed aspects and how they affect the nature of transition.

Energy policy, and attempts to use it to enable low carbon transition, needs to be understood as being contingent upon a range of other political institutions that may, or may not, support such change. Many have observed that existing political institutions can do as much to

hinder as to support low carbon transition (Jacobs 1991; Bernstein 2001; Carter 2007; Giddens 2009), whilst it is also clear that there are other, non-climate objectives that energy policy is driven towards achieving. STT scholars have argued that in addition to profound change to existing technologies and infrastructures other practices, political and social, need to significantly alter (Meadowcroft 2005: 483; Kern 2011b: 1116). What needs to be considered, therefore, is how energy policy can provide this function given the claim that current political institutions need to change in order to do so. Without in depth understandings of how energy policy currently works, and in the absence of conceptualisations of how political institutions change, we are left with a proscribed theoretical model for energy transition governance but with few means of understanding transition policy processes underway.

One final critique of STT conceptualisations of transition is that questions of how transition takes place are under-explored, and within that there has been little exploration of how policy fits into that process beyond as idealised 'enabler'. One recent paper has, for example, suggested that '…the destabilisation of regimes is assumed to happen…' but how and why destabilisation might occur is seldom explored in detail (Turnheim and Geels 2012: 35). Smith et al have suggested that it is the way in which pressures upon a system are articulated that can enable conditions for profound change (2005). However it has also been observed that there are multiple pressures upon current energy regimes to change – some of which may not be complimentary to low carbon transition (Shove and Walker 2010). In addition, Berkhout et al have claimed that there has been too much emphasis on exogenous drivers for change and on suggesting replacement policies but not enough articulation of ways in which existing energy regimes are failing (2003: 3). As such, not only are the broader political contexts within which transition governance takes place underexplored but the nature and degree of consensus regarding climate change and environmental pressures is oversimplified thereby making the formulation of visions appear less contested.

2.1 Energy Policy as Contingent on Political Institutions

One way of developing a better understanding of the politics of energy transition is through analyses of the institutions and ideas that currently inform energy policy choices and structures (Kern 2011b; Meadowcroft 2011) hence the application here of a largely sociological institutionalism (Hall 1993; Campbell 1998; Blyth 2002; Hay 2002; Schmidt 2002; Widmaier et al 2007). New institutionalist theories of institutional change have little to say specifically about low carbon transitions, but in application to theorising the role of energy policy in managed transitions we can learn more about how ideas, such as knowledge about climate change but also other political ideas, colour and constrain transition. They can also reveal

more about the ways in which power inter-relations are currently structured and what kinds of impacts these have on the nature of transition.

STT literatures have emphasised the ability of rules and norms to constrain technological choices and here likewise energy policy choices are understood as being influenced by sets of rules and norms that encourage certain choices over others. In order to understand better how rules and norms are constituted we can understand them as being contingent upon interpretive frameworks, or policy paradigms. These influence decision-making both during times of stability and change. Ideas are, in this way, understood as explanatory variables that can help us to understand why some energy policies, for example, might be chosen over others – or as part of the 'why' of analysing actions (Hay and Wincott 1998: 953). Although some policy paradigms, once accepted, can become so deeply embedded within political institutions that they become 'taken for granted' (Hall 1993: 279), they are also contested by alternative narratives with greater or lesser degrees of success at points in time. Certainly today there are a variety of approaches to energy policy, as to economic policy more broadly, that dominate decision-making within different socio-political settings (Schmidt 2002).

In attempting to better understand the context within which energy policy for transition proceeds we can look at how ideas, as interpretive frameworks influence decision-making. Ideas in this sense are understood at the cognitive level, as elite assumptions that constrain the range of useful solutions and policy choices available to policymakers (Campbell 1998: 385). Ideas influence policy-making on a number of different levels – how a policy area is perceived as well as what the objectives and instruments of policy should be (Hall 1993: 279). Policy objectives, as a reflection of collective values, are fundamental to conducting policy towards certain outcomes (Strange 1988: 16) – indeed knowledge about climate change finds its political articulation largely through the means of target setting. Interpretive frameworks also influence the structure and mandates of those institutions that are given responsibility for governing a policy area, or indeed what if any political capacity will be assigned to that area. It is this ability to influence objectives and instruments of policy and to shape political institutions that make ideas so important to include as explanatory variables, in addition to interests and material factors.

Most observers of energy policy over the past decades agree that it has been influenced by neoliberal economic ideas – in particular in OECD institutions such as the European Commission, the International Energy Agency (IEA) as well as in countries like the US and the UK (Helm 2003; Mitchell 2008; xxx). Increasingly it has been understood that freely trading energy markets, based on commodity trading, would allow for greater economic and managerial efficiencies, increasing competition and reducing monopolistic practices in energy

supply (Webb 1985; Mitchell et al 2001). Markets were also understood as capable of delivering the historically important objective of energy security and for this reason establishing free markets then became the principal energy policy objective for a wide range of governance actors (see Author 2 this special issue). This approach might be accused of confusing means, i.e. competitive international markets, with ends, i.e. energy security – a point to which we return below. This is not to say that neoliberal economic ideas dominated exclusively, but just to claim that energy policy had been heading in a more neoliberal direction from the early 1980s onwards.

The objective of establishing freely trading energy markets was pursued largely through, not uncontested, processes of privatisation and deregulation across OECD and emerging and transitioning countries from the early 1980s onwards – starting with Chile and the UK. Policies of privatisation and deregulation became enshrined as 'good governance' practice within international institutions including the IEA, the International Monetary Fund (IMF) and the World Bank where energy reform was often part of lending conditions (de Oliveira and MacKerron; Author 4 this special issue). Ultimately in many countries the private sector became central to the delivery of energy goods and services and to facilitating investment in, often vital, new energy capacity and infrastructures. In some countries, like the UK, where privatisation and liberalisation were taken furthest large energy corporations have also become the main conduit through which energy policy can be enacted. This has inferred important and particular power relations between policymakers and private energy industries and financiers. As a result of these power relations the private sector, particularly large energy and finance companies, have enjoyed a higher degree of influence in that maintaining business confidence and conditions became, and remain for many, key state concerns (Meadowcroft 2005: 492).

Neoliberal economic ideas have also historically coloured climate policy through a process sometimes referred to in climate governance literatures as the 'compromise of liberal environmentalism' (Bernstein 2001; see also Newell and Paterson 2010). It has been argued that

> *... economic ideas overshadowed scientific ideas and ecological thought in producing normative compromises at key junctures in the evolution of the environmental norm-complex over the last thirty years* (Bernstein 2001: 190)

In this way pre-existing politico-economic institutions have indeed been influenced by scientific knowledge about anthropogenic climate change but they have resisted other more radical environmental ideas about how to govern for climate change mitigation. A recent book on climate capitalism claims that by the time responses to climate change became better established, notably in the Kyoto Protocol of 1997, the sorts of strategies being developed had

been determined by free-market ideologies and the dominance of energy companies and other financial actors (Newell and Paterson 2010: 11). This can be partly explained by the core service and financing roles observed above that the private sector was by then assumed to hold but it has allowed mainly large-scale energy businesses to influence policy and to defend existing (fossil fuel) assets and business models against change. In practice, therefore, embedded pro-market ideas have established rules and norms that favour established companies and non-disruptive technologies which slot relatively easily into the institutional regime.

The ability of fossil fuel companies to oppose change and influence policy was further aided by a broad lack of energy policy-making capacity – unsurprising given the relative withdrawal of state institutions from energy. Depoliticisation of energy was, as observed above, supposed to improve energy security by reducing the ability of states to act in international markets (Cherp and Jewell 2011: 4). The extreme example of the withdrawal of political capacity was the UK where, from 1992 to 2008, there was no Department for Energy. But aside from defined interest groups like the IEA and OPEC and attempts to extend WTO rules to energy via the Energy Charter Treaty (ECT), energy did not exist as a discrete area for international governance (Lesage et al 2010). Given the degree to which responsibility for energy had been passed to the private sector current political institutions are not equipped to indulge in precisely the kind of deliberative governance so recommended by TM scholars. Low carbon transition policy-making, through learning-by-doing, deliberation and co-ordination, requires a degree of commitment and a level of ongoing, active institutional capacity not currently available in most countries – with the exception, perhaps, of Germany (see Mikler and Harrison 2010).

A further, important aspect of the political context within which energy transition takes place is the role that publics play – in this sense as voters. STT literatures focus on publics as end users of energy services, whose practices collectively need to change, and also sometimes as activists within civil society organisations. Here we touch on ideas as public sentiments in that public assumptions can also constrain the normative range of energy policy objectives and instruments (Campbell 1998: 385). Although popular understandings of anthropogenic climate change are growing there is, currently, little widespread public support for climate policies in a great many countries. Arguments about energy security policy have often figured quite high on popular and political agendas, for example at times of general elections in countries like the United States and Russia, but climate change mitigation policy is not yet a vote grabber in most countries of the world, and in some may still be a vote loser. Thus climate change mitigation is rarely a big part of electoral politics, or high up on Parties' manifestos – this is of

note given that general elections can serve as an opportunity for political change (see Hall 1993).

2.2 Energy Policy as Specific

As suggested above perceptions of energy as a policy area, and its politico-economic role, can also be influenced by interpretive frameworks. From a neoliberal economic perspective energy was understood more as replaceable commodity, particularly fossil fuels, or as a service to be provided by the private sector (Cherp and Jewell 2011). Under this conceptualisation energy could become subject to generalised economic policy requiring neither a national energy policy nor, necessarily, energy experts to devise policy. As such in many OECD countries, especially the UK which had privatised and liberalised energy to an extent not seen elsewhere, perceptions of the socio-economic importance of energy diminished within the context of an increasingly service, consumption and accumulation led economy (Paterson 2010). Energy policy had become subsumed within broader neoliberal economic institutions, not least given the central marketisation objective, rather than set towards achieving specific energy policy objectives.

By stark contrast, however, energy can also be perceived as having a fundamental socio-economic role in terms of input into production and economic growth, in terms of public access and development (see Introduction this special issue), not least in BRIC countries like China, Russia and Brazil. China's considerable international search for energy supplies, often pursued by state-owned entities, is most often ascribed to China's need for reliable energy supplies to underpin economic growth. This understanding is now common across many political institutions but energy's role is further underpinned for many net-exporting countries by the percentage of GDP that comes from export revenues. In such countries popular and elite perceptions of energy companies as national, collective and/or strategic assets are more commonplace. This is partly why energy has qualified for specific governance choices, for example in Russia when the state increased its ownership of large energy corporations in the mid 2000s this approach was not extended to other sectors. Assumptions about energy's role in underpinning economic growth, in providing jobs and a certain quality of life also helps to explain why energy is still subsidised in some consumer and producer countries (see Author 3 this special issue). In that they support existing fossil fuel systems such subsidies serve to inhibit new energy solutions but are difficult to break in many countries given existing social contracts and the importance of access to affordable energy across society.

This suggests that analysis of some sectors, such as energy, should be specific and not made subject to general rules of economic management. One recent critique of the varieties of

capitalism approach suggests that beneath generalisations about ways in which state-market relations can be structured within countries there exists a much wider variety of political choices and actions (Crouch 2005: 442). Even within market economies, where neoliberal economic ideas have been more dominant, responsibility for certain goods and services, such as medical, educational and welfare goods, still lie with the state. For example:

> *… an extremely powerful, scientifically oriented military sector, tying a number of contracting firms into close… relations with central government departments, is a fundamental attribute of the US economy, and central to much of its innovative capacity* (Crouch 2005: 442)

The practice of support for innovation in certain sectors also contrasts with common assumptions about freely trading markets as principal cites for radical innovation (Hall and Soskice 2001).

As such within market economies sectors can be treated differently – some subject to processes of depoliticisation, privatisation and liberalisation whilst in others state actors remain closely involved. This begs the question of how some areas become chosen for state support and investment over others. Some services are broadly perceived as national public goods, subject to public support and/or policy, whilst others are not but understanding how these decisions are made is highly important if a case is to be made for a high degree of state involvement in energy transition. The example given above of the role that state entities have historically taken in diffusing various technologies – not least in the roll out of national electricity systems – is illustrative of notion of energy services as public good (Perez 2002). As such it is clear that energy can be understood as being socio-economically important enough to warrant direct state support in both market and more state-oriented economies – the question remains one of timing, framing and context and of how such arguments relate to other policy areas.

3. The Nature of Energy Policy Change

The influences of political institutions over energy transition explored thus far have helped to shed some light on the gap between idealised models of governance for energy transition and many current practices but they have perhaps emphasised path dependency more than change. This section seeks greater understanding of how and why profound political change takes place through the application of concepts of institutional change, in particular that of punctuated evolution (Hall 1993; Hay 2002; Blyth 2002). Importantly both STT and institutional literatures understand profound change with reference to Thomas Kuhn and as implying a departure from existing practices (Kuhn 1962). The notion of punctuated evolution suggests

that the rate of change within and to institutions is not consistent but at the same time does not negate the notion that change is always ongoing, or in STT terminology that regimes are always evolving. Punctuation, however, offers an opportunity for moments of more rapid and intense transformation within longer periods of more modest institutional change (Hay 2002: 161). This opportunity for more rapid transformation is understood to be of some relevance here given claims from economic historians that previous, 'organic' energy system transitions have taken place over considerable periods of time and the urgent aspects of low carbon energy transition outlined above.

Punctuated evolution as a concept is in some respects not dissimilar to STT conceptualisations of transition taking place when a socio-technical regime becomes destabilised allowing an opportunity for alternative technologies to break through (Foxon 2011: 2259). Furthermore change is enabled, from both perspectives, when there is recognition that a problem exists and that current socio-technical institutions are not addressing these problems – conditions which often occur at moments of crisis and uncertainty (Verbong and Loorbach 2012: 6; Widmaier et al 2007: 748).[iii] Punctuated evolution, in addition, tells us more about the actual process of change in that it proposes that narratives, underpinned by alternative interpretive frameworks, are enablers of agency and change. Crises, importantly, are understood not as self-apparent phenomena but as needing to be narrated and explained and narratives therefore, in addition to arguing that crisis exists and that existing institutions are failing, need also to successfully explain the crisis and provide related policy solutions (Blyth 2002: 9-10). Theoretically whichever narrative succeeds in the battle to create new political institutions will influence how the policy area is perceived and the choice of policy objectives, instruments and institutions. In this way the *nature* of institutional change that takes place can be explained in relation to whichever crisis narrative prevails in the battle to convince audiences that their version of events and solutions is correct.

In order to understand the nature of current energy policy change, and how it relates in particular to low carbon energy transition, we need therefore to explore the narratives and ideas that are currently driving change. This suggests that narratives are not only competing to influence change but are also, to an extent, succeeding in doing so. STT analyses have emphasised the potential role of new scientific knowledge about anthropogenic climate change in destabilising existing energy regimes and informing new objectives. International climate governance literatures have emphasised the ability of free market capitalism to influence energy policy choices (Bernstein 2001; Carter 2007; Newell and Paterson 2010).

This paper claims that narratives about energy problems and how they should be solved do not stop here. Energy policy debates in OECD countries have been dominated by at least

three principal narratives, based on different schools of thought about energy, its function and how to govern it (xxx; see also Cherp and Jewell 2011). The pro-market narrative, based largely on neoliberal economic thought, has been actively competing with climate change narratives but also with energy security narratives, informed by geopolitical ideas, to inform how energy systems should change. Both energy security and climate narratives suggest that energy is in crisis but they explain crisis in very different ways. Energy security narratives are most often expressed with reference to a national, or in the case of the EU a regional, entity. They emphasise arguments about greater competition between states to access dwindling fossil fuel reserves that lie within sovereign boundaries, and the corresponding need for the state to take a greater role in securing energy markets and trade (see Klare 2008). Energy security narratives have sought, like climate narratives, to highlight market failure, to contest the dominant role of markets in energy provision and the paucity of state responses thus far.

In some countries the energy security narrative has had a greater degree of influence over others within processes of change to energy policy and these changes largely support existing fossil fuel infrastructures. Exporting nations like Russia, Argentina and Venezuela, which had privatised their energy companies in the 1990s, have more recently enacted energy governance changes that explicitly reject the 'Western', generic free market model in recognition of the vital socio-economic functions that energy plays (Goldthau 2012). China likewise holds energy security to be of primary importance, with an focus on supply reliability and affordability, and this has underpinned extensive energy diplomacy and state support for national oil companies' attempts to develop new fossil fuel resources internationally. This is not to suggest that ideas about low carbon transitions and new technologies have had no impact in such countries, both China and Russia are pursuing policies to support new technologies on both energy efficiency and environmental grounds, but that energy security (of supply and/or demand) sits currently at the top of a hierarchy of objectives.

The situation is, however, more complex in many OECD countries and institutions. Climate and geopolitical framings of energy crisis have both had a degree of influence over energy policy change - not least in that they have influenced the adoption of new energy policy objectives. State institutions in addition have recently been taking a more active role in energy governance and market intervention in a number of OECD countries (Helm 2005; Kern 2011b). Energy policy, as a result, is now focused on climate change mitigation, maintaining energy security and, for some, also on the alleviation of energy poverty – referred to collectively as the 'Energy Trilemma' (see Introduction this special issue). What arguably makes energy policy so complex but also interesting is the degree to which the market framing persists alongside geopolitical and climate framings. EU energy policy, for example, is now set towards meeting

three objectives that reflect each of the simultaneously dominant framings: competitive markets, energy security and climate change mitigation (EC 2011). The EU is continues with its programme of liberalisation and internal market integration whilst also intervening politically to establish new infrastructures such as the Nabucco pipeline (see Author 1 this special issue). UK energy policy elites, as another example, have recognised market failure in energy and the need for state intervention, but intervention framed as temporary - until markets have re-established equilibrium (xxx).

In contrast therefore to those countries that have emphasised energy security there appears in many OECD countries to be no explicit preference or stated hierarchy between pro-market, climate change and geopolitical understandings of energy governance. The pro-market energy governance system has been simultaneously responding to a range of alternative framings by setting energy policy towards achieving new objectives. What further complicates matters from a low carbon perspective, however, is the suggestion that energy security and poverty objectives may not always be compatible with climate change objectives (Diesendorf 2009). For example different framings of energy interact with existing energy interests in different ways: the security narrative prefers stability and supports existing energy infrastructures whilst the climate framing clearly supports the development of new technologies and infrastructures. The costs of transitioning energy infrastructures whilst maintaining energy security have implications for energy poverty – particularly instances where these costs are passed on to consumers. The potential tensions between different framings of energy and objectives are, however, seldom overtly recognised or debated in policy documents. Instead assumptions are increasingly made about the degree to which energy policy objectives can be mutually compatible (IEA 2007). Rightly or wrongly policies like improving energy efficiency and producing more energy from domestic renewable sources are understood to meet both energy security and climate change mitigation objectives simultaneously.

Recognising the degree to which current energy policy is, in some countries and governance institutions, directed at achieving multiple objectives can help to explain change as being driven by a range of 'best stories' about energy - even in those countries where the climate narrative has found most political and public support. Climate change objectives are being balanced constantly with other forces influencing energy policy change - in ways that compromise and constrain low carbon energy transition and often support existing over new technologies and infrastructures. Given observations above that not all objectives may be conducive to low carbon energy system change this in turn partly explains why emerging energy governance is in considerable danger of under-delivering on low carbon energy

transition. These observations not only remind us of the degree of ongoing contestation within energy governance change but they also return us to the notion that existing and new technologies and infrastructure need to be taken into account when considering energy policy change and its role in energy transitions.

Conclusions

Following on from STT literatures that have highlighted the importance of policy, often of a certain kind, to low carbon energy transition this article has sought to explain that political institutions constrain, enable and colour system change differently according to various institutional contexts. It is argued here that in formulating understandings of the politics of transition we need to consider general ideas about economic governance as explanatory variables, but also ideas that are specific to energy – its perceived socio-economic role and how it should be governed. STT literatures have provided a range of insights - not least in conceptualising a regime as including infrastructures and technologies, such as fossil fuels, in addition to other social structures. This, amongst other things, forces a realisation that despite decades of debate about climate change mitigation the fossil fuel regime remains overwhelmingly dominant. A second valuable insight has been an outlining of the ways in which this transition differs from previous energy system shifts and the urgency of changes required. All of this underpins the importance of energy policy to transition and a realisation that policy needs to change to meet mitigation goals before the consequences become irreversible.

This article has conceptualised changes to energy policy as taking place not just as a result of new knowledge about climate change but within the context of pre-existing political institutions that reflect the dominance of capitalism, often of a neoliberal economic nature. An emphasis on pre-existing ideas and institutions has helped to provide explanations of how energy system change has been influenced in ways that support existing fossil fuel infrastructures and companies. This highlights how an important inter-relationship between two areas of energy systems, politics and technology, has functioned in practice. The concept of punctuated equilibrium might offer a route through which energy policy could be altered sufficiently to better support low carbon transition. However, the ways in which energy problems are currently being framed, and associated institutional changes, suggest an ongoing and bitter struggle between energy narratives and ideas rather than the radical shift towards one cohesive set of solutions that some STT analysis infers. Fossil fuel regimes are being challenged by new climate objectives for energy policy, including targets for renewable energy, but at the same time they are being reinforced by energy security framings of energy policy.

Neoliberal ideas are being contested by climate change and geopolitical framings of energy but they persist in influencing institutions such as the IEA, and in the EU and the UK in particular. Energy policy change is characterised here as being driven by multiple sets of interpretive frameworks that drive it in different directions. Energy policy, particularly in OECD countries, is as a result becoming increasingly complex but arguably also contains an ever-growing number of under-recognised internal tensions. It is, perhaps, the persistence of such internal tensions that might allow those interested in a lower carbon energy system to instigate a more radical punctuation of energy policy in future – but only if low carbon transition can be credibly related to wider socio-economic values and objectives.

References:

Berkhout, Frans; Smith, Adrian; Stirling, Andy (2003) 'Socio-technical regimes and transition contexts', a *SPRU Electronic Working Paper*, No. 16, June 2003, University of Sussex.

Bernstein, Steven (2001) *The Compromise of Liberal Environmentalism.* New York: Columbia University Press.

Blyth, Mark (2002) *Great Transformations: Economic Ideas and Institutional Change in the Twentieth Century*. New York: Cambridge University Press.

Campbell, John L. (1998) 'Institutional Analysis and the Role of Ideas in Political Economy', *Theory and Society* 27, 3, pp. 377-409.

Carter, Neil (2007) *The Politics of the Environment: Ideas, Activism, Policy: Second Edition*. Cambridge: Cambridge University Press.

Chang, Ha-Joon (2009) 'Industrial Policy: Can We Go Beyond an Unproductive Confrontation?', A Plenary Paper for ABCDE (*Annual World Bank Conference on Development Economics*), Seoul, 22-24 June 2009.

Cherp, Aleh; Jewell, Jessica (2011) 'The three perspectives on energy security: intellectual history, disciplinary roots and the potential for integration', *Current Opinion in Environmental Sustainability*, 3, pp. 1-11.

Crouch, Colin (2005) 'Models of capitalism', *New Political Economy* 10, 4, pp. 439-456.

de Oliveira, Adilson; MacKerron, Gordon (1992) 'Is the World Bank approach to structural reform supported by experience of electricity privatization in the UK?', *Energy Policy* February 1992, pp. 153-162.

DECC (Department of Energy and Climate Change) (2012). *2011 UK Greenhouse Gas Emissions, Provisional Figures and 2010 UK greenhouse gas emissions, final figures by fuel type and end-user*. London: DECC.

Diesendorf, Mark (2012) 'Can Energy Security and Effective Climate Change Policies Be Compatible?', in Luca Anceschi and Jonathan Symons (eds.) *Energy Security in the Era of Climate Change*. Hampshire and New York: Palgrave Macmillan.

EC (European Commission) (2011) *Energy 2020: A Strategy for Competitive, Sustainable and Secure Energy*. Brussels: Directorate-General for Energy.

Fouquet, Roger (2010) 'The slow search for solutions: Lessons from historical energy transitions by sector and service', *Energy Policy* 38 (2010), 6586-6596.

Foxon, Timothy J. (2011) A coevolutionary framework for analysing a transition to a sustainable low carbon economy', *Ecological Economics* 70 (2011), pp. 2258-2267.

Geels, F.; Schot, J. (2007) 'Typology of sociotechnical transition pathways', *Research Policy*, 36, 399-417.

Goldthau, A. (2012) 'From the State to the Market and Back: Policy Implications of Changing Energy Paradigms', *Global Policy* 3, 2, May 2012, 198-210.

Grubb, M.; Haj-Hasan, N.; Newbery, D. (2008) 'Accelerating innovation and strategic deployment in UK electricity: applications to renewable energy', in M. Grubb, T. Jamasb, M.G. Pollitt (eds.) *Delivering a Low-Carbon Electricity System: Technologies, Economics and Policy*. Cambridge: Cambridge University Press.

Hall, Peter (1993) 'Policy Paradigms, Social Learning, and the State: The Case of Economic Policymaking in Britain', Comparative Politics, 25, 3, pp. 275-296.

Hall, Peter; Soskice, David (2001) 'Introduction', in Peter A. Hall and David Soskice (eds.) *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage*. Oxford: Oxford University Press.

Hay, Colin (2002) *Political Analysis: a Critical Introduction*. Basingstoke: Palgrave Macmillan.

Hay, Colin (1996) ‘Narrating Crisis: The Discursive Construction of the Winter of Discontent’, *Sociology* 30. 2, pp. 253-277.

Hay, Colin; Wincott, Daniel (1998) ‘Structure, Agency and Historical Institutionalism’, *Political Studies*, XLVI, pp. 951-957.

Hayward, S. (1998). ‘Towards a political economy of biotechnology development: A sectoral analysis of Europe’, *New Political Economy* 3, 1, 79-101.

Helleiner, Eric (2004) ‘Economic Liberalism and Its Critics: The past as Prologue?, *Review of International Political Economy* 10, 4, pp. 685-696.

Helm, Dieter (2005) ‘The Assessment: the New Energy Paradigm’, *Oxford Review of Economic Policy* 21, 1, 1-18.

IEA (International Energy Agency) (2012) World Energy Outlook 2012. Paris: OECD/International Energy Agency.

IEA (2007) *Energy Security and Climate Policy: Assessing Interactions*. Paris: OECD/ International Energy Agency (IEA)

Jefferson, M. (2008) ‘Accelerating the transition to sustainable energy systems’, *Energy Policy* 36, 11, 4116-4125.

Katzenstein, Peter (2009) ‘Mid-Atlantic: Sitting on the knife’s sharp edge’, *Review of International Political Economy* 16, 1, 122-135.

Kemp, R.; Schot J.; Hoogma, R. (1998) ‘Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management’, *Technology Analysis & Strategic Management* 10, 175-195.

Kern, Florian (2011a) ‘Using the multi-level perspective on socio-technical transitions to assess innovation policy’, *Technological Forecasting & Social Change* 79, 298-310.

Kern, Florian (2011b) ‘Ideas, institutions, and interests: explaining policy divergence in fostering ‘system innovations’ towards sustainability’, *Environment and Planning C: Government and Policy* 2011, 29, 1116-1134.

Kern, Florian; Howlett, Michael (2009) ‘Implementing transition management as policy reforms: a case study of the Dutch energy sector’, *Policy Sciences* 42, 391-409.

Kuhn, Thomas (1962) *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.

Lesage, Dries; Van de Graaf, Thijs; Westphal, Kirsten (2010) *Global Energy Governance in a Mutipolar World*. Surrey, England; Burlington, USA**.**

Lovell, Heather; Bulkeley, Harriet; Owens, Susan (2009) ‘Converging agendas? Energy and climate change policies in the UK’, *Environment and Planning C: Government and Policy* 2009, 27, 90-109.

Markard, Jochen; Raven, Rob; Truffer, Bernhard (2012) ‘Sustainability transitions: An emerging field of research and its prospects’, *Research Policy* 41 (2012), 955-967.

Meadowcroft, James (2011) ‘Engaging with the politics of sustainability transitions’, *Environmental Innovations and Societal Transitions* 1 (2011), 70-75.

Meadowcroft, James (2005) ‘From welfare state to ecostate’, in J. Barry and R. Eckersley (eds.) The State and the Global Ecological Crisis. MIT Press.

Mikler J. and Harrison N. (2012) “Varieties of Capitalism and technological innovation for climate change mitigation” *New Political Economy* 17, 2: 179-208.

Newell, Peter; Paterson, Matthew (2010) *Climate Capitalism: Global Warming and the Transformation of the Global Economy*. Cambridge: Cambridge University Press.

Paterson, Matthew (2010) ‘Legitimation and Accumulation in Climate Change Governance’, *New Political Economy* 15, 3, 345-368.

Penna, Caetano C. R.; Geels, Frank W. (2012) 'Multi-dimensional struggles in the greening of industry: A dialectic issue life-cycle model and case study', *Technological Forecasting & Social Change* 79 (2012), 999-1020.

Perez, Carlota (2002) *Technological Revolutions and Financial Capital*. London: Edward Elgar.

Rip, A.; Kemp, R. (1998) 'Technological Change', in S. Rayner and E. L. Malone (eds.) *Human Choices and Climate Change Volume 2: Resources and Technology*. Columbus, Ohio: Battelle, 327-399.

Rotmans, Jan; Kemp, René; Van Asselt, Marjolein (2001) 'More evolution and revolution: transition management in public policy', *Foresight* 3, 1, 15-31.

Schmidt, Vivien (2002) *The Futures of European Capitalism*. Oxford: Oxford University Press.

Schot, J. W. (1998) 'The usefulness of evolutionary models for explaining innovation. The case of the Netherlands in the nineteenth century, *History of Technology* 14, 173-200.

Scrase, Ivan; Smith, Adrian (2009) 'The (non-)politics of managing low carbon socio-technical transitions', *Environmental Politics* 18, 5, 707-726.

Shove, Elizabeth; Walker, Gordon (2010) 'Governing transitions in the sustainability of everyday life', *Research Policy* 39 (2010), 471

Smith, Adrian; Voß, Jan-Peter; Grin, John (2010) 'Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges', *Research Policy* 39 (2010), pp. 435-448.

Smith, A.; Stirling, A.; Berkhout, F. (2005) 'The governance of sustainable socio-technical transitions', Research Policy 34, 10, 1491-1510.

Turnheim, Bruno; Geels, Frank W. (2012) 'Regime destabilisation as the flipside of energy transitions: Lessons from the history of the British coal industry (1913-1997), *Energy Policy* 50 (2012) pp. 35-49.

van den Berg, J.C.J.M.; Faber, A.; Idenburg, A.M.; Oosterhuis, F.H. (2007) *Evolutionary Economics and Environmental Policy: Survival of the Greenest*. Cheltenham and Northampton M.A.: Edward Elgar Publications.

Verbong, Geert; Loorbach, Derk (2012) 'Introduction', in Geert Verbong and Derk Loorbach (eds.) *Governing the Energy Transition: Reality, Illusion or Necessity?*. Abingdon and New York: Routledge.

Voß, Jan-Peter; Bauknecht, Dierk; Kemp, René (2006) *Reflexive Governance for Sustainable Development*. Northampton MA: Edward Elgar.

Webb, Michael G. (1985) 'Energy policy and the privatization of the UK energy industries', *Energy Policy* February 1985, pp. 27-36.

Widmaier, Wesley; Blyth, Mark; Seabroke, Leonard (2007) 'Exogenous Shocks or Endogenous Constructions? The Meanings of Wars and Crises', *International Studies Quarterly* 51, 747-759.

[i] Notions of sustainability have evolved over time – but it is here taken to mean that human energy usage and practices do not harm the environment, deplete natural resources, and services are more equitable and affordable.

[ii] This is mainly a reference to corporate entities, both individually and as organised groups. Clearly differentiation should be made between companies that resist low carbon change and those that are currently working actively to enable low carbon transition (Penna and Geels 2012: 1000).

[iii] This association of crisis, uncertainty or shock with opportunity for change is common across a wide range of very different academic disciplines, ecology, psychology, sociology, biology, economics and technology studies.