Theorising governance and innovation in sustainable energy transitions

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Abstract:

Understanding why and how it is that some countries are able to implement policies which lead to deeper and faster change in sustainable practices and outcomes is an important step in enabling an acceleration in the transition to a sustainable energy future. This paper presents a tentative, provisional framework for analysing energy system transition, differential outcomes and the reasons for them. It suggests that energy system rules (in enabling or blocking change) and incentives (in making change economic or not) play an important role in shaping change. A provisional hypothesis is that the UK's ability to make the transition to a sustainable energy system is constrained by the nature of its institutional system and policy paradigm; and because of this, a critical precondition for more innovation in the UK is the implementation of an appropriate governance system. A key insight is a need to understand 'how and why' policies are implemented, of 'how and why' changes in practices and outcomes are driven, and the links between the two. A provisional Theory of Managed Energy Transition is put forward that seeks to: firstly identify the linkages of politics, actors and agency to the 'how' and 'why' of energy policy implementation and delivery; and secondly, relate these to changes in practice and outcomes.

Keywords: Change; Climate Change; Energy; Institutions; Sustainability; Transition

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1. Introduction

At the heart of the question of whether prosperity can be made environmentally sustainable is the question of sustainable energy. As ecological economics has reminded us, energy is essential to the modern economy and standard of living; not just consumption but also the provision of public goods such as health and education. Thus perhaps the most important environmental challenge currently is how to make the production and use of energy sustainable.

The idea of a transition to a more sustainable energy system is not new. In 1976 Amory Lovins argued that the US faced a choice between two "energy paths":

> '*The first path resembles present federal policy and is essentially an extrapolation of the recent past. It relies on rapid expansion of centralized high technologies to increase supplies of energy, especially in the form of electricity. The second path combines a prompt and serious commitment to efficient use of energy, rapid development of renewable energy sources matched in scale and in energy quality to end-use needs, and special transitional fossil-fuel technologies. This path, a whole greater than the sum of its parts, diverges radically from incremental past practices to pursue long-term goals'* (Lovins 1976: 65)

Lovins characterised these two paths as "hard" and "soft" energy paths respectively. What is striking almost 40 years later is that we are still pondering over this same choice. For many years after Lovins's article was published most countries, helped by cheap fossil fuels and the long time it has taken the climate problem to gain recognition, have simply continued along the hard energy path. It is only relatively recently that renewable energy and an emphasis on energy efficiency have entered the mainstream. In some countries, while a great deal has changed in terms of targets and aspirations, less has altered in terms of structural change and practical outcomes. Other countries, however, do seem to be moving along a soft energy path. Thus, energy paths are becoming increasingly divergent, with some countries showing much more rapid and sustained movement than others (Tables 1 and 2, Figure 1). In particular the UK appears as a laggard, especially in relation to some other European comparators.

It is commonly argued that sustainable energy transitions should emerge from a process of interaction between stakeholders, for example, as with the transitions management approach (e.g. Loorbach 2010). However, for the purposes of this paper, our main focus of interest is how far countries manage the growth of renewable energy and the demand side of energy, especially high levels of efficiency, low overall demand and flexibility in demand. This emphasis on soft energy paths arises from the observation that scenarios of future energy systems with these elements dominating are almost inevitably the ones that achieve environmental sustainability at lowest overall cost (for a review see Steward 2013). Demand in particular is key since the lower demand is, the lower the requirement for supply, and the more flexible demand is, the more that naturally variable renewable supply can be accommodated without the need for expensive storage (Mitchell 2000 and 2002).

Table 1
Generation of electricity from renewable sources, excluding hydropower
1990 -2010, selected countries

	Electricity generated (TWh)			Electricity generated (% of total)		
	1990	**2000**	**2010**	**1990**	**2000**	**2010**
UK	0.6	4.8	22.2	0.2	1.4	6.6
Germany	1.5	11.7	83.1	0.3	2.0	13.2
Denmark	1.7*	5.5	12.4	5.2*	15.8	34.8
California	~25.6	24.0	25.6	12.0	9.7	8.8

Note: *1994

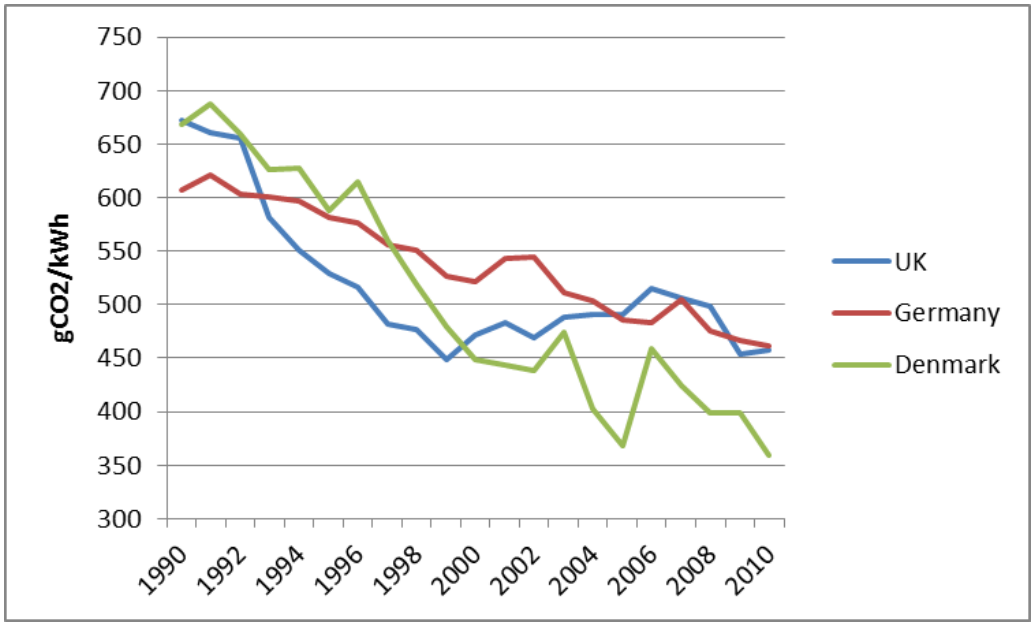
Sources: UK – DECC (2012) UK Renewable Energy in Brief, http://www.decc.gov.uk/assets/decc/11/stats/publications/energy-in-brief/5942-uk-energy-in-brief-2012.pdf; Germany – BMU, BEE, AGEB; Denmark – Danish Energy Agency, http://www.ens.dk/en-US/Info/FactsAndFigures/Energy_statistics_and_indicators/Annual%20Statistics/Sider/Forside.aspx; California – California Energy Commission, Wiser et al (1998), *Energy Policy* 26, 6: 465-75

Table 2
Indicators of energy efficiency, selected countries

	UK	Germany	Denmark
Energy intensity of industry (koe/€2005p value added)	0.118	0.90	0.110
Energy intensity of manufacturing (koe/€2005p value added)	0.150	0.143	0.125
Energy consumption per dwelling scaled to EU average climate (toe/dwelling), 2010	1.69	1.33	1.51

Source: Oddyssee - Energy Efficiency Indicators in Europe, http://www.odyssee-indicators.org/

Figure 1:Carbon intensity of grid electricity



Source: International Energy Agency

The evidence above immediately prompts the questions of why Britain has been so poor, relative to other countries, at making the energy system sustainable and what would accelerate an energy transition in Britain. Understanding why and how it is that some countries are able to implement policies which lead to deeper and faster change in such sustainable practices and outcomes is a first step towards enabling the UK to implement policies to accelerate the transition to a sustainable energy future. This paper presents a tentative, provisional framework for analysing energy system transition and differential outcomes. Our aim is to develop a theoretical framework for explaining both why it has taken so long for progress towards a more sustainable energy system in industrialised countries (and especially the UK), and why there is divergence in that progress between different countries.

Within these broad parameters, there are likely to be multiple routes in practice to a more sustainable energy system. Denmark, for example, has much more decentralized production of energy than do other countries. There may also be pauses or temporary reversals in policy, as in California's investment in renewables. A full understanding of sustainable energy transition requires an understanding of these aspects of change as well.

The paper argues that while various existing theories of energy and other technological transitions offer useful insights into this area, ultimately they do not deal sufficiently with the question of 'how and why' policies are implemented, of 'how and why' changes in practices and outcomes are driven, and the links between the two. The central, while provisional, hypothesis of this paper is that the UK's ability to make the transition to a sustainable energy system is currently constrained by the nature of its institutional system and policy paradigm. This suggests that a critical precondition for more innovation in the UK is the implementation of an appropriate governance system. The provisional theory of transition set out in this paper – a theory of managed energy transition - is thus differentiated from other theories of transition because of a focus on, and then marrying of, two aspects: firstly, the linkages of politics, actors and agency to the 'how' and 'why' of policy implementation; and secondly, a focus on change in practice and outcomes (see below section 2).

We argue that existing theories of transition have an inadequate account of politics, do not provide sufficient clarity about the role of agency[1] in the energy system and do not provide an explanation of comparative difference in movement towards transition between countries. We then go on to develop a theoretical framework that does have these characteristics, in a series of steps. First, we adopt an institutionalist frame of analysis which can incorporate the influence of power, material and political interests, discourse and the path-dependence on the formation of institutional systems and change. Second, we draw on the varieties, or models of capitalism school of comparative institutional analysis to help understand why there is divergence between countries in which different specific institutional systems and discourses pre-dominate. However, these institutionalist approaches have been developed not for the study of energy transitions, but rather mostly for understanding differences and change in underlying economic and political institutions and outcomes. The next step in the paper is therefore to consider what the key relevant institutions and actors in the energy sector are, and how an institutionalist approach might be applied specifically to energy transitions. Finally, based on this analysis, we develop a comparative framework for

[1] Foxon (2011) defines agency as the capacity for actors to actively influence change

understanding why different countries with different underlying economic and political institutional systems and policy paradigms might be expected to make progress towards sustainable energy systems at a different pace.

This argument is developed over sections 3 to 7. As a preliminary, in the next section we make explicit what we mean by an energy transition, and define our key terms. Section 3 discusses the currently dominant approach to thinking about energy transitions – socio-technical transitions theory. Section 4 introduces institutionalist theory. In section 5, comparative institutional analysis in the form of the varieties of capitalism literature is discussed. Section 6 considers how institutionalist theory might be applied to the energy sector, and section 7 presents our framework and some key implications arising from it.

2. Characterising the nature of energy transitions

As a preliminary to the review of existing approaches, it is helpful to lay out what we see as the nature of an energy transition and thus to frame the exact questions we wish to ask. Many current definitions of sustainability transitions frame them as fundamental and multi-dimensional changes to a whole system. For example, in a recent review, Markard et al (2012: 956) note that in the socio-technical transitions literature, a transition is defined as "a set of processes that lead to a fundamental shift in socio-technical systems" involving "far–reaching changes along different directions: technical, material, organizational, institutional, political, economic and socio-cultural." *Sustainability* transitions are further described as "long-term, multi-dimensional and fundamental transformational processes through which established socio-technical systems shift to a more sustainable mode of production and consumption".

As has been widely noted by others (e.g. Unruh 2000, Smith et al 2005, Meadowcroft 2005, Scrase and Smith 2012, Fouquet 2010, Kuzemko 2013), the transition to a sustainable energy system is, in the words of Berkhout et al 2004, a 'normatively driven, purposive' transition. In many other technological transitions, technological innovation and markets have been the key drivers of change. Such innovation has still been facilitated by wider institutions, especially by intellectual property arrangements and government investment in networks and complementary technologies etc., but in a sustainable energy transition the role of deliberate attempts to create rules, incentives and institutions to drive the transition is distinctive. As Markard et al put it "(o)ne particularity of sustainability transitions is that guidance and governance often play a particular role" (Markard et al 2012: 956).

These characterisations of sustainable transitions are important but in certain ways they do not specify the core nature of the changes that are involved. Here we put forward a view on this issue. Our starting point is that we see an energy transformation or transition ultimately in terms of *changing practices* by the full range of actors in the energy system, ranging from electricity generators to wholesalers, supply companies, network operators, energy service providers and users of energy. Such changes might, for example, involve selling energy services in retail markets rather than selling electricity and gas, investing in renewable electricity generating technologies rather than conventional gas turbines, or even down to domestic consumers choosing a more energy efficient appliance or a small business deciding to fit automated lighting controls

linked to movement sensors. Doing things differently, whether in terms of business models or investments in new technologies or new ways of using energy, in the direction of a soft energy path, is what we mean by *innovation*. In this sense, following others, we take a broad view of what constitutes innovation. Specifically, the invention of new technologies may play a relatively minor role in sustainable energy transitions, compared with other changes.

We argue that a key issue for understanding why transitions occur or do not is that many important practices on the supply side, especially investment in or providing and selling energy or energy services, can only happen for any length of time if they are financially sustainable, i.e. you can make money from them. This is certainly true in contexts where these activities take place in the private sector, but it is also important for public sector companies, community ventures and private households. Financial viability also, crucially, applies to innovation, including technological innovation. This is not a *sufficient* condition for a practice to be maintained, as there may be other barriers, but it is often a *necessary* one. Actors in the energy system (e.g. generation, wholesale, retail companies, consumers) undertake practices when all barriers, including that of financial sustainability, are removed. How far actors can make money, and the extent to which other enablers or barriers to action exist, depends on the detailed *rules* (regulations) and *incentives* (revenues, including support mechanisms etc., less costs and adjusted for risks) in the energy system. This is the focus of the sub-field of energy economics (e.g. Bhattacharyya 2011). However, we see these rules and incentives in turn as shaped by the nature of underlying *institutions* in the energy system, including how energy markets are structured, how networks and capital markets are governed etc. This is what we understand by *governance*.

It follows that *whether and how far a country's energy system moves towards a soft transition path depends on the rules, incentives and institutions in the system*. This approach to the core nature of energy transitions, understood in terms of changing practices, rules and incentives and underlying institutions, together with the context of the diverse experience between countries noted above, leads us to frame the key questions about Britain's poor relative record on sustainable energy transition as follows:

a) *Why have rules, incentives and institutions in different energy systems evolved in the different ways that they have?*

b) *Why have rules, incentives and institutions in the energy systems of some other countries moved further and faster towards a soft energy transition than Britain's?*

The challenge for theory is to provide potential answers to these questions which can also act as a guide for empirical research and, ultimately, policy analysis and political strategy. The remainder of this paper seeks to develop a framework that meets these criteria.

3. The socio-technical transitions approach

The leading body of theory on sustainable energy transitions is the socio-technical transitions (STT) approach (Shove and Walker 2007). The STT literature goes back several decades (Scrase and Smith 2012: 709) and is now very large. In this approach, a socio-technical transition is conceptualised as change from one relatively stable state of the socio-technical system to another (Geels 2002, Rotmans et al 2001). Such systems are conceptualised as complex structures made up of a wide range of different areas across industry, technology, politics, and society (Turnheim and Geels 2012). Transitions similarly 'entail new technologies, but also changes in markets, user practices, policy and cultural meanings' (Geels 2010: 495, see also Geels 2002: 1257). Thus, transitions are profound and large-scale transformations (Verbong and Loorbach 2012: 6). Low carbon transition in particular is understood 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).

Transitions do not come about easily, because elements in a socio-technical configuration are linked and aligned with each other (Geels 2002: 1258). There are patterns of lock-in 'that relate to sunk investments, behavioural patterns, vested interests, infrastructure, favourable subsidies and regulations' (Geels 2010: 495). In the case of high-carbon energy systems, Unruh (2000) provides the standard reference on lock-in. In these circumstances, radically new technologies have a hard time breaking through because regulations, infrastructure, user practices, maintenance networks all aligned to existing technology. However, transition is nevertheless possible, and historically has been achieved on many occasions.

In explaining how this may happen, STT theory uses the concepts of '*regimes*', '*niches*' and '*landscapes*' (Geels 2002, 2004, Geels and Schot 2007, Rip and Kemp 1998).[2] The regime, which constitutes mainstream ways of realising various social functions, provides the 'selection environment' for new technologies and other innovations (Smith et al 2010: 440). In the multi-level perspective versions of STT, the socio-technical regime is a very broad concept, incorporating not just Nelson and Winter's (1982) idea of 'technological regimes' consisting of the routines of engineers and firms, and Rip and Kemp's (1998) 'rule-set' of complex engineering practices, skills, product characteristics embedded in institutions and infrastructures, but also the rules and practices of other groups, including: 'users, policy makers, societal groups, suppliers, capital banks etc.' Geels (2002: 1259-60). These sets of rules and practices stabilise existing trajectories but also, importantly, blind actors to new developments outside their focus (Geels and Schot 2007: 400).

Change and innovation does occur within regimes, but is incremental in nature. By contrast, radical innovations of the type usually associated with socio-technical transition are generated in niches. This is where radical novelties, with an emphasis on technical innovation which can pioneer new ways of constituting and satisfying social demands, are understood to emerge (Kemp et al 1998; Geels and Schot 2007). They are not just about R&D, but also processes such as learning-by-doing, and building up supportive social networks including, supply chains etc. (Geels 2002: 1261). Niche

[2] According to Geels (2002: 1259) these different 'levels' are to be understood not as distinct ontological entities but rather as analytical concepts or views on a single reality (see also Geels and Schot 2007: 399).

technologies initially tend to have poor technical performance and are expensive. These novelties are 'initially unstable…configurations' and as such niches need to act as 'incubation rooms' protecting novelties against mainstream market selection (Kemp et al 1998; Schot 1998).

Technological trajectories – whether changing incrementally or radically - are situated in a socio-technical landscape (Rip and Kemp 1998), described as a set of deep structural trends. Examples given are oil prices, economic growth, wars, emigration, broad political coalitions, cultural and normative values, environmental problems (Geels and Schot 2007: 400; Smith et al 2010: 440). From the point of view of the regime and niches, the landscape level represents the 'external structural context'.

Within this framework, 'transitions, which are defined as regime shifts, come about through interacting processes within and between these levels' (Geels 2010: 495). Niches are understood as exogenous sites of 'revolutionary change', in contrast to regimes that tend to reproduce normal innovation patterns (Smith 2010: 440). However niches can only break through, 'if external landscape developments create pressures on the regime that lead to cracks, tensions and windows of opportunity' (Geels 2010: 495) (see also Kemp et al 2001, Geels and Schot 2007, Kern 2011, Smith et al 2005). The recognition of climate change can be one such pressure.

3.1 A critique of the STT approach

What does this body of theory on socio-technical transitions imply for our key research questions raised above? Transition is more likely to take place where an alignment between landscape pressures on a regime and the presence of niche innovations trying to break through takes place. In the case of a purposive transition, i.e. where actors (governments) are trying to accelerate transition, this implies that transition will happen faster where niches are better nurtured or managed (i.e. through better 'strategic niche management' – see Kemp et al 1998, Caniëls and Romijn 2008, Smith and Raven 2012), and where landscape factors tend to put more pressure on regimes, or are mobilised to do so.

Such a way of looking at transition is useful. However, from the point of view of the comparative institutionalist perspective we take on transitions here, it suffers from a number of limitations. The first is that an account of politics in this approach is underdeveloped (Kuzemko 2013). In that they are about large-scale and profound changes, transitions imply not only new methods and practices but also that different social groups, for example new producers, distributors and retailers, will benefit from the process of transition while others may well lose out (Fouquet 2010: 6591). This is partly why some incumbent groups are heavily involved in pitching their often not inconsiderable economic and political power at resisting change, or at least at influencing what kind of change takes place (ibid 2010: 6592).[3] Yet despite claiming a central role for policy in transitions and whilst emphasising the existence of complex inter-dependencies between areas, the socio-technical literature has been criticised for not analysing politics or political decision-making in any great detail (cf., Meadowcroft 2005, 2009, 2011, Fouquet 2010: 6591, Kern 2011). There has been a tendency to focus on proscribing what individual policies could or should be rather than questioning

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

the political and institutional circumstances that make the adoption of certain policies likely (Meadowcroft 2011: 73; cf. Shove and Walker 2007: 4). As a result, the politics of managed transition can come across as being quite straightforward in theoretical discussions, when the reality has been quite different in many countries (cf. Kern and Howlett 2009).

The absence of an analysis of politics is problematic in particular when considering the claim here that sustainable energy transition is, to a large extent, a *managed* transition (Smith et al 2005, Markand et al 2012: 957). All socio-technical transitions have political dimensions. As Meadowcroft (2005: 488) puts it: 'Conflict is often rife, with technological development and economic rivals disputing the course of development and resistance coming from those on whom the costs of change are to be imposed (lost jobs, environmental externalities, regional decline, and so on).' However, those transitions that will need to be driven by policy and hence ultimately by politicians, are even more deeply political in nature. Although socio-technical transition theories allow for a constitutive role for culture, interpretive frameworks, historically embedded norms and power structures, more needs to be done to understand these aspects and how they affect policy choices, rules, regulations and practices (cf. Markand et al 2012: 956; Scrase and Smith 2009: 710; cf. Smith et al 2005: 1508).[4] Indeed, while the need for a stronger account of politics in the socio-technical transitions literature has now been frequently made, and while particular elements of such an account have been explored (e.g. Meadowcroft 2009 and 2011; Kern 2011; Kuzemko 2013; Kern et al 2014 forthcoming), a systematic framework that draws on contemporary political theory is still largely lacking.

A second limitation of socio-technical transitions theory is that the concepts used (especially regime and landscape) are very broad and all-encompassing. In one sense, this inclusiveness is desirable because of the multi-dimensional nature of transitions (Smith et al 2010: 437-440). However, without further analytical specification of how actors and institutions in niches, regimes and landscapes are expected to interact with one another, the explanatory power of the approach is limited. There is little sense of hierarchy or of whether and how some things matter more than others. The landscape concept does not necessarily help us understand comparative differences in the pace and direction of change. For example, one important landscape factor is scientific knowledge about climate change which puts pressure on current regimes of energy production and consumption, but this is common to all countries, and so does not go very far in explaining why regime responses vary so much.

Geels (2002: 1259) describes the MLP perspective as an "appreciative theory", which Nelson (2007: 1) defines as theory that attempts 'to capture the basics of what is going on' and Nelson and Winter (1982) describe as having a 'focus on the endeavor in which the theoretical tools are applied' as opposed to formal theory which focuses on 'improving or extending or corroborating the tool itself'. This approach is thus in the interpretative tradition of Weber's *verstehen*.[5] It functions well as a form of rich description, and is well-suited to the post-hoc interpretation of case studies which are

[4] This lack of a more developed account of politics in such theories may be in part because, as Meadowcroft (2005: 486) notes "…the notion of 'transition' is drawn primarily from literatures on technological change", rather than on politics or sociology.

[5] Often translated as 'understanding' – see, for example, Ritzer and Stepnisky (2013, Ch 4)

the main form of empirical study in the STT literature.[6] As Smith et al (2010: 441-42) put it, the MLP 'provides a language for organising a diverse array of considerations into narrative accounts of transitions.'[7] However, the range and heterogeneity of factors in the landscape, the complexity and number of processes in the regime and in niches, and the fact that a number of different regimes and niches may interact (Smith et al 2010, Raven and Verbong 2007) mean that each case is likely to be different; 'each transition is historically contingent', as Smith et al (2010: 443) put it. Such approaches are of limited use in the case of managed transitions where policy actors will look to analysis to guide them on the most important actions that they can take.

In a recent paper, Turnheim and Geels (2012) appear to seek to address such gaps with a new sub-theory of why regimes become unstable. They put forward a 'triple embeddedness' framework for analysing regime dynamics in a particular industry (ibid: 37). Industry actors are understood as located in an 'industry regime', that is 'a set of industry-specific institutions…that enable and constrain behaviour and action' (ibid: 37). At the same time, they are influenced by developments in the economic environment (i.e. supply chains and markets) and the socio-political environment (i.e. relationships between industry actors and policy makers, civil society and the public), but also act to influence them, via economic and innovation strategies, political strategies, including lobbying, and public relations, etc. This framework departs from previous MLP explanations in its focus on particular economic and political elements in the landscape and in some respects it resembles the framework we develop below. However, it remains quite general, and other than listing potential elements of that environment, does not say anything about how these might be structured, or how and why we might see differences in environments between countries.

3.2 The co-evolutionary approach to transitions

Some of these issues also apply to Foxon's (2011) recent attempt to build on the socio-technical transitions literature and evolutionary economics in a 'co-evolutionary' approach to the issues and challenges in overcoming lock-in to high carbon systems. The framework aims at an analysis of low-carbon transitions, and it draws on a wide range of other disciplines. Foxon argues that change is the outcome of interactions between five key elements or systems: eco-systems; technologies; institutions (including regulatory frameworks, property rights and standard modes of business organisation); business strategies (defined as 'the means and processes by which firms organise their activities so as to fulfil their socio-economic purposes' (Foxon 2011: 2262)), and user practices.

These different systems evolve under their own dynamics, as well as co-evolving with each other, mutually influencing each other in a similar way to that posited by the MLP for different levels of the socio-technical system. For example, user practices, which play an important part in shaping the demand for energy, can be influenced by technologies, business practices, and institutions, which can enable or constrain

[6] E.g. Turnheim and Geels (2012) on coal in the UK, Geels (2002) on steam ships, Verbong and Geels (2007) on the Dutch electricity system, Raven and Verbong (2007) on combined heat and power in Holland, and Kemp et al (2001) on wind power in California and Denmark, and the case studies in *Research Policy* 39, 4

[7] Note that Smith et al (2010) criticise the MLP approach for *too much* abstraction. Here, the argument is that a degree of abstraction is needed in an explanatory approach useful for guiding action, but that it needs to be a more specific type of abstraction.

particular practices. Foxon suggests that the co-evolutionary approach gives a single framework where change across the micro, meso and macro levels of the energy system can be considered, whilst taking account of the dynamics within systems, as well as the causal interactions between them, at these different levels. The framework also links to the idea of transition pathways (see above).

The co-evolutionary framework represents an attempt to capture the complexity, dynamic interactions and mutual stability that can exist between differing elements and actors in the energy system. It goes beyond the MLP approach by seeing regimes as the outcome of interactions between specific groups of actors, emphasising the importance of agency in influencing change within and between the different systems. It partially meets Malerba's challenge for co-evolutionary research (2006: 18, quoted in Geels 2010): 'to go to a much finer analysis at both empirical and theoretical levels, and to move from the statement that everything is coevolving with everything else to the identification of what is coevolving with what, how intense is this process and whether indeed there is a bi-direction of causality'.

However, Foxon's framework also has some limits. It does not provide much detail on what is contained within each system, and importantly, what is happening and who is involved in the interactions between them. It also does not really specify how we expect these different elements to interact, why they would interact in different way in different countries or why the interaction would change over time. As with the MLP approach, the co-evolutionary framework can be usefully applied retrospectively to different case studies, but does not yield any specific hypotheses about difference or change for prospective comparative research.

In conclusion, the socio-technical literature on sustainable energy transitions has several strengths. It points to the highly complex and dynamic nature of transitions generally, but also the fact that the current need is for a transition that is unprecedented in contrast to previous large-scale energy transitions in a number of respects, including in its urgency compared with previous large-scale energy transitions (Fouquet 2010) and the need for active management of the transition through policy. However, it is also clear that approaches in the socio-technical transitions school are of limited use for explanatory comparative analysis aimed at engaging with policy makers and politicians, partly because it remains too broad and descriptive, and partly because it lacks a good enough account of politics.

4. New institutionalist theories

In the previous section we argued that the dominant theory of sustainable energy transitions, the socio-technical transitions framework, is limited in its applicability to the question of why governing institutions in energy systems in some countries have moved further and faster towards a sustainable transition than in others, and why such institutions evolve the way they do. The answers it provides are too broad, and in particular do not sufficiently consider the politics of change, despite the fact that the processes of sustainable transitions are so inherently political.

This critique implies that to understand energy transitions in comparative perspective we need a theory of institutions and institutional change that has an account of politics, while at the same time capable of explaining comparative difference. Moreover, the review of the socio-technical transition literature also identified further desirable criteria

for a theory of sustainability transition. As in Foxon's approach, it should explain current practices and outcomes (including investment in and the development of technologies), as well as transitions, as emerging from the dynamic interaction between actors and the systems they create, intentionally or unintentionally, i.e. it must have an account of agency.

A good starting point for identifying such a theory is the 'new' institutionalism that has come to play a central role in political theory over the last 30 years. As Hall and Taylor (1997: 936) emphasise, this is not a unified body of thought, but rather a number of different approaches to institutional analysis, each with different theories of agency and models of institutional change. These include historical institutionalism, rational choice institutionalism, sociological institutionalism, and what has been termed discursive or ideational institutionalism (e.g. Campbell 1998).

One of the older streams of institutionalist theory, historical institutionalism, is characterised by a particular emphasis on path dependence, through the constraints or inertia imposed by existing institutions, and on unintended consequences. It is also theoretically one of the most eclectic schools, incorporating both power and ideas as determinants of institutional change (Hall and Taylor 1997: 937-39). However, for this very reason, other competing accounts of institutional form and change have evolved that are based on more specific theories of action.
Rational choice institutionalism in political science is closely related to the development of new institutional economics.[8] In this analysis, "actors have a fixed set of preferences or tastes…behave entirely instrumentally so as to maximize the attainment of these preferences, and do so in a highly strategic manner that presumes extensive calculation." Hall and Taylor 1996: 944-45). These preferences are in practice often identified with material gain, political power or electoral advantage. The institutions that emerge from these strategic interactions are seen as arrangements that minimise transactions costs (Coase 1937, Williamson 1985, North 1990) and solve collective action problems (Ostrom 1990). Because the existence of institutions is typically explained by reference to their functions, they tend to be seen as socially optimal arrangements and therefore inherently stable (Hall and Taylor 2006: 945-46).

An exception is the 'social conflict' school of new institutional economics (e.g. Acemoglu et al 2005), where political and economic institutional arrangements, both formal and informal are not seen as optimal for the whole of society, but rather as maximising the benefits for those actors with the most political power. Their emphasis on the primacy of *political* power, whether wielded through formal political institutions or informally through military or economic means, is particularly useful and is returned to below. However, even the social conflict school sees institutional arrangements as stable in the absence of exogenous drivers of change, since they tend to represent the choices of the most powerful actors in the system, who have no incentive to change them (while other actors do not have the power to do so).

Thus accounts of institutional change in rational choice institutionalism, as with socio-technical systems theory, are weaker in terms of explaining why institutions tend to persist (Kingston and Caballero 2008). Indeed, in such approaches the main explanations for institutional change are exogenous 'shocks', such as shifts in relative

[8] For recent overviews see: Chavance 2009, Ménard and Shirley 2008, Alston 2008 and Brousseau and Glachant 2008

prices (see also Geels 2010: 497). In some versions, these exogenous changes include technological change. This is clearly problematic from the point of view of analysing how change might come about in the case of managed technological transitions, since they are precisely about trying to bring about such shifts from within existing institutional systems. Moreover, the assumption that actors always know what is in their interests has been criticised (Blyth 2002), as has been the lack of acknowledgement that that interests are not at least to some degree socially constructed.

By contrast, sociological institutionalist approaches view behaviour not as the strategic pursuit of fixed material or political interests but rather as driven by a search for legitimacy, status or social appropriateness, defined in culturally specific ways (Hall and Taylor 1996: 949). Institutions are then seen as about the transmission of cultural knowledge. The interpretation of what 'institutions' are is then much broader than in the rational choice approach, i.e. "not just formal rules, procedures or norms, but the symbol systems, cognitive scripts, and moral templates that provide the 'frames of meaning' guiding human action." (ibid: 947).[9] This aspect of the theory emphasises how actors in an institutional system will gain esteem from knowing how to conform to existing cognitive frames and routines, and therefore how hard it is for individuals in institutions to go against the conventional wisdom, since this will typically involve loss of status, marginalisation or worse.

The emphasis on the cognitive aspects of the formation is even more central in 'discursive institutionalist' theories that give a central place to the role of ideas, especially broad, paradigmatic ideas about politics and policy (Hall 1986, Campbell 1998, 2002; Berman 1998; Blyth 1997, 2002, Jacobsen 1995). In Campbell's (1998, 2007) account, ideas work at two levels. One is at the level of underlying assumptions about what is feasible in institutional or policy terms. These assumptions are informed cognitively by sets of ideas often referred to as an interpretive framework or a policy paradigm (cf. Hall 1993; Schmidt 2008), which influences and limits the definition of propblems and the range of possible solutions to them (Campbell 1998:378, Meadowcroft 2011: 73), and normatively by what Campbell calls 'public sentiment', i.e. public opinion, which plays a key role in shaping the policy agenda (e.g. Page and Shapiro 1983, Kingdon 1995, Stimson et al 1995, Burstein 2003, Hobolt and Klemmemsen 2005). Within these broad constraints, ideas are deployed by actors in the foreground of policy debate, both in the form of framing problems and solutions in ways that resonate with public opinion and the dominant paradigm, and in the form of practical policy programmes (Campbell 1998: 385). On this view, politics can be understood as a struggle for power played out in significant part through arguments about the 'best story' (Fischer 2003: x), where the audience is made up of elites and stakeholders but also, importantly, the voting public. Policy paradigms and public sentiment influence decision-making on a number of different levels, including how policy problems are prioritised and defined, as well as what the objectives of policy should be and which instruments can be used to attain these objectives (Hall 1993: 279).[10] Institutional change in discursive institutionalism is then understood in terms of

[9] The sociological institutionalist approach has its roots in organisation theory, which also provided some of the core ideas about 'routines' in socio-technical systems theory, via Nelson and Winter's account of technological systems.

[10] One application of this kind of approach to the energy sector is Kern's (2011) study of two contrasting institutions for innovation in the Netherlands (the Energy Transition project) and the UK (the Carbon Trust). Kern shows how interest-based explanations offer some useful insights into why different types of institution were chosen, but argues that an analysis of the role of broader discourses shaping both interests and political salience is also needed.

the deployment of new ideas. Incremental change can happen within paradigms or without major shifts in political opinion, either through strategic action (Campbell 2007) or through institutions drift and decay (Streeck and Thelen 2009). But radical change is more likely to take the form of the erosion of the power of a policy paradigm, often at times of crisis, and its replacement by another (Hall 1993, Oliver and Pemberton 2004). These different approaches within institutionalism thus emphasise different aspects of institutional formation, function and change, including material or political interests, symbolism or ideas, strategic behaviour and the constraints of existing institutions. Nevertheless, as Hall and Taylor (1996: 955) note these approaches 'share a great deal of common analytical ground', and in certain combinations can complement one another. New institutionalism thus provides accounts of institutional change involving material and political interests and ideas that are widely used in mainstream political science. These theories have little to say specifically about energy transitions, but in application to theorising the role of governance in managed transitions we can learn more about how interpretive frames can colour and constrain change and about the role of public sentiments. They can also reveal the ways in which power inter-relations are currently structured within and between political and market institutions and actors within specific socio-political contexts.

However, while institutionalist theories do provide a good account of the politics of institutional change, they do not in themselves provide the kind of comparative explanatory analysis required for understanding why different countries are moving at different speeds and pathways in transition to more sustainable energy systems. Rather, it is in the *application of new institutionalist approaches to the comparative study of diversity within capitalism* that we can find we can find such an analysis, and to which we now turn.

5. Varieties of capitalism

One of the most important applications of the new institutionalist theory has been in the exploration of institutional diversity in capitalist economies and the implications of that institutional diversity for economic performance. Following the early contribution by Michel Albert (1993), two key linked concerns in the literature have been: how far differences in economic institutions between countries affect the competitiveness of those countries against each other (e.g. Crouch and Streeck 1997, Hall and Soskice 2001, Dore et al 1999), and how far globalisation and the spread of a liberal market ideology has reduced or eradicated national differences (e.g. Berger and Dore 1996, Schmidt 2002, Hall 2007). More recent literature has also been concerned with understanding how institutional change works in different comparative settings (e.g. Crouch 2005a, Streeck and Thelen 2005, Hancke et al 2007).

5.1 Common themes in the literature

There are many debates within this area of theory, including how many varieties of capitalism need to be distinguished, and what type of institutionalist theory should be at the fore. Hall and Soskice (2001, 2003) take a rational choice approach to institutions as solutions to minimising transactions costs, which provides some clear hypotheses about comparative advantage of different systems in types of innovation. However, as a

variant of institutional economics, this approach produces quite a static account, and others, such as Crouch and Schmidt have tried to produce more dynamic accounts in which ideas play a greater role, especially in explaining differential rates of institutional change across countries. Nevertheless, despite these differences there are a number of themes common across all these approaches which are relevant for the development of a theory of sustainable energy transitions that can be applied comparatively.

The first of these common themes is that different countries are characterised not by differences in random contrasts in individual institutions but rather that different countries have different *systems of institutions* that have co-evolved and that are generally inter-locking and mutually supportive. Such systems are not immutable, and are not always found to the same extent in all sectors of the economy (Crouch 2005b), but they are nevertheless dominant enough to characterise economies of being of a particular type. These national differences in dominant institutional systems have been eroded to some degree by globalisation, but they are far from having been eradicated.

A second common theme is that, amongst the types of capitalism that various authors have claimed to identify most accounts include some variant of a *contrast* between what are commonly termed '*coordinated*' or '*managed*' institutional systems in north-western Continental Europe (with Germany as the paradigmatic case) and '*liberal*' or '*market*' systems in Anglo-American countries (the UK being the paradigmatic case within Europe). In Hall and Soskice's (2001: 8-9) approach, liberal market economies are characterised by arm's-length exchange between firms characterised by competition and formal contracting. By contrast, firms in coordinated market economies depend more heavily on non-market relationships, which entail 'more extensive relational or incomplete contracting, network monitoring based on the exchange of private information inside networks, and more reliance on collaborative, as opposed to competitive relationships'. Hall and Soskice's main focus is on inter-firm relationships, but other accounts argue that states in liberal and coordinated capitalism have roles that co-evolved with these different institutional systems. Thus Schmidt (2002: 113) argues that in liberal market economies government has the character of an liberal arbiter, with arm's-length relationships with the private sector, whereas in coordinated, or managed, capitalism, the state plays the role of the an enabling facilitator, with a negotiated relationship with firms.

Schmidt (2002) and Campbell (2004) also emphasise the role of ideas, and especially policy paradigms, in the evolution of different institutional variants of capitalism under the pressures of liberalising globalisation and a homogenising Europeanization. Schmidt argues that in Britain policy has been dominated by a neo-liberal paradigm and a politics deeply influenced by Thatcherism (2002: 257-302). These cognitive and normative ideas became so strongly established partly because of the depth of the crisis that the previous regime of Keynesian policy paradigm, corporatist politics and 'club' governance faced in the 1970s (Hall 1993, Moran 2003). By contrast, a liberal policy paradigm has not become so deeply entrenched in Germany, partly because of a distinctive 'social market' paradigm and political discourse that was established after the Second World War, and which helped shape Germany's deliberative economic institutions, and partly because those institutions themselves make it harder for policy elites in government to impose paradigm change unilaterally.

A third common theme in the varieties or models of capitalism literature is the *focus on the basic institutions* of the economy. These include: labour markets and the organisation of training; corporate governance and how firms access finance; and how

relationships between firms in supply chains is managed. The comparative advantage of different countries, including the types of innovation that they might do better at than others, is then seen as arising from these institutions, rather than just from a narrower set of institutions in national innovation systems. Hall and Soskice, for example, argue that firms in liberal market economies will tend to lead in radical innovation because of the flexibility in labour market and inter-firm relationships found in such economies, while firms in coordinated market economies will tend to excel at incremental innovation (Hall and Soskice 2001: 36-44).[11]

More recent research has extended the scope of contrasts to *political institutions* and redistribution. Cusack et al (2007) argue that coordinated economies tended to adopt proportional representation (PR) electoral systems wholesale in the early 20th century, whereas liberal market economies retained majoritarian (or first-past-the-post) systems. At the same time Iversen and Soskice (2006) argue that proportional representation is linked to higher levels of welfare provision (see also Austen-Smith 2000 and Crepaz 1998 on inequality under different sets of political institutions).

Overall then, the variety or models of capitalism approaches emphasise that certain policy choices and institutional structures might not necessarily be 'right' or 'wrong' but rather should be seen as related to specific domestic political and institutional contexts as well as interests, material factors and power relations. The value of the approach is that it allows us to hypothesise at a specific level that the UK's model of liberal market capitalism and related political institutions may explain why the UK energy system takes the form it does, why the regime has been particularly resistant to change, why niche protection is less effective and why landscape factors have been less destabilising than in more managed or coordinated market systems (Germany, Denmark).

5.2 Varieties of capitalism and energy sector analyses

The literature on the comparative institutions of capitalism has been developed with a focus on the basic institutions of the economy, rather than with a specific focus on the energy sector or on questions of sustainability. The models of capitalism approach may help explain why it has been easier for Germany, as a coordinated economy, to take this transition route as opposed to the UK as a liberal market economy. For example, this may be partly because managing long-term planning and coalition building represents a greater part of Germany's institutional make-up. Public sentiment may also be more supportive of sustainable energy transition, with more deeply entrenched support for notions of collective action to reach social goals as well as a higher degree of popular support for 'green' ideals and wider spread belief in the notion of anthropogenic climate change. However, while these observations suggest the ways in which energy policy is related to broader sets of ideas about politics, for example about individualism and collectives, they provide us with relatively little detail about the specific effects of rules and regulations on energy systems and the extent to which they are or are not progressing the energy system towards an environmentally and socially sustainable future. Neither do they tell us much about the actions and motivations of other stakeholders within energy systems – such as end users or incumbent and emerging energy companies. At the same time, as Crouch (2005b) notes, institutional

[11] Hall and Soskice's predictions on patterns of innovation have been challenged (Taylor 2004, Akkermas et al 2007).

systems and policy paradigms do not necessarily have the same degree of coherence and power in all sectors.

There have in fact been relatively few attempts to apply comparative institutional and discursive analysis to energy. Mikler and Harrison (2011) use Hall and Soskice's varieties of capitalism framework to evaluate the potential of the automobile industries in Germany and the US to develop electric vehicles. The core of their argument is that coordinated market economies like Germany are institutionally more suited to the governance of innovation for a sustainable energy transition than market economies, since '(t)he type of individuality encouraged by neoliberal visions of capitalism, in particular, discourages consciously coordinated collective action and that is clearly necessary to overcome a global catastrophe' (Mikler and Harrison 2011: 2).[12] Coordinated economies have institutional capacities that can better enable the coexistence of high levels of economic performance alongside the pursuit of other social goals, capacities not as readily available to purer market economies (Crouch 2005a: 441). This is of course of particular significance in the context of a managed transition, where coordination of efforts is a basic prerequisite (see above and Meadowcroft 2005: 485).

Kern (2011) does not explicitly use the varieties of capitalism framework, but does offer a comparative analysis of institutions for sustainable energy innovation in the UK (the Carbon Trust) and the Netherlands (the Energy Transition project) in terms of interests, discourses and existing institutions. He argues that the form of intervention in each country was heavily influenced by dominant interests and institutions (arms-length support to businesses in the UK vs. a coordinative approach building on the consensual 'polder' model in the Netherlands) and that the degree to which these interventions led to real innovation depended on how far the discourses of innovation transformed existing interests and challenged existing institutions (Kern 2011: 1129).

Both of these analyses are useful in demonstrating how comparative institutional frameworks can be applied to the analysis of element in sustainable energy transitions. However, they also both focus directly and quite narrowly on institutional arrangements for technological innovation, rather than for broader processes of transition, which are as much about investment and market transformation as about technological innovation per se.

A third study, Mitchell's (2008) account of the UK energy system and its poor record on sustainability, does deal with the wider structure of the sector. She develops the concept of a "band of iron" determining the nature of governance of the energy system in the UK – a set of institutions and ideas at the heart of the existing energy system (i.e. the regime) which mean that, despite the existence of specific support policies for renewable energy and energy saving (niches), very little progress is actually made. Her account of the band of iron draws heavily on Moran's (2003) concept of the post-privatisation 'regulatory state paradigm', which allowed the emergence of large energy incumbents who shape policy to their own advantage, excluding more innovative actors from markets, underpinned by a wider policy paradigm of market liberalism. Mitchell's analysis is interesting in that it considers not just the direct influence of the policy

[12] These observations appear to directly contradict claims made by Hall and Soskice that LMEs are better at producing radical innovations and developing 'future-oriented' sectors of the economy whilst CMEs are more likely to have declining economic sectors (Hall and Soskice 2001). However, Mikler and Harrison's distinction is less between radical and incremental innovation and more between market-driven vs. socially driven innovation.

paradigm on policy design but also the indirect effects of the paradigm on innovation via incumbent power and market structure. In a sense, the approach proposed here may be seen as an extension of this approach.

6. Applying an institutionalist approach to the energy sector and energy transitions

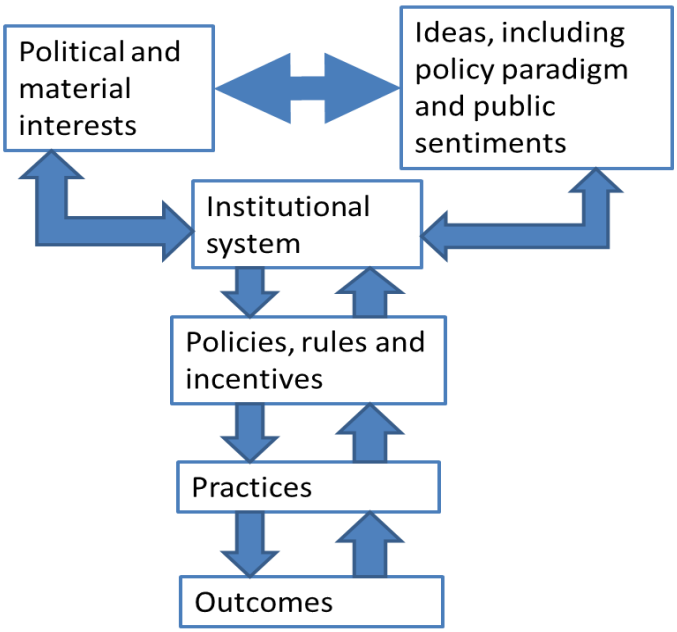
In the final two sections of this paper we build on the examples in section 5.2 to provide a more general theory of how a comparative institutionalist approach can be applied to sustainable energy transitions.

6.1 An institutionalist perspective on practices and outcomes

In our discussion of the nature of transitions in section 2 above, we argued that it is changes in practices by actors in the energy system and the resulting outcomes that ultimately characterise a transition, and that these are in turn are largely shaped by the rules and incentives that the governing institutions of the energy system generate. Drawing on the institutionalist approach outlined above in section 4, we can see these institutions as evolving in the interaction between political and material interests, policy paradigms and public sentiments, and the inertia of existing institutions, including wider economic and political institutions outside the immediate sector (Figure 2).

We are conceptualising this as a non-linear, interactive framework. Key roles are played by policy paradigms, and by political projects that mobilise and resonate with majority public opinion (for example, Thatcherism in the 1980s). Policy paradigms become embedded institutionally not only through influencing what policy objectives, instruments and rules are put in place, but also the design of the political institutions established to govern areas of policy (Kuzemko 2013: 51). These, in turn, also have implications for practices and outcomes at commercial, industrial and individual levels – for example within energy systems. There are thus interactions between different levels of the governance system, the policy paradigm, the objectives, instruments and rules, the structure of energy institutions and public sentiments. As suggested in Figure 2, influence flows both ways; the policy paradigm and underlying political project are ultimately affected in turn by outcomes, since if they are negative for long enough, they create a crisis. For example, in the energy sector, a policy paradigm which generated very high prices, low security of supply and a high degree of pollution would not be politically sustainable.

Figure 2: An institutionalist perspective on practices and outcomes



It will be clear from this account that our focus is mainly on the politics and economics of transition, with less emphasis on elements that play a greater role on the socio-technical transitions literature, such as technical routines, user practices and indeed, technologies. This is because, although not always straightforward, user practices and routines are often susceptible to change where there are sufficient economic incentives or political will to transform the nature of energy demand (e.g. Unruh 2002: 319). Technological factors matter less for comparative analysis because technologies are largely available everywhere, and so cannot play a *major* role in explaining differences between country pathways and speed of transition. By contrast, historical investments in particular technologies (and especially infrastructure) do create major path-dependence, and so these do play a more significant role in our approach (see below).

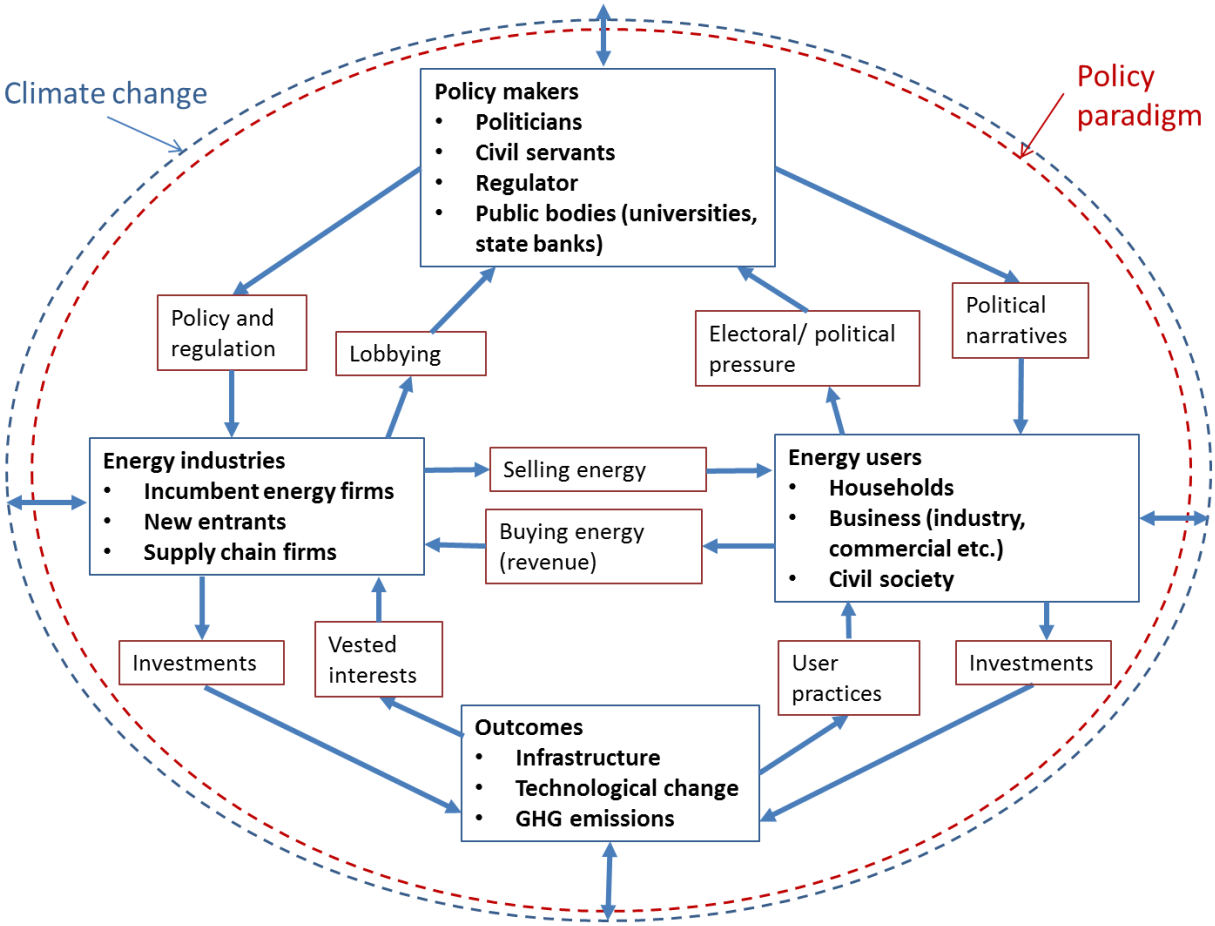
6.2 Actors, agency and interactions

However, at this level the analysis is very general. To be more useful for explanatory analysis, we argue that we need to assess more specifically where the elements of dominant institutional systems, policy paradigms and interests are likely to be important within the energy sector. For this assessment we need to characterise the energy sector, and (following Foxon 2011) especially the politically and economically significant groups of actors, since it is these actors who have interests, who shape and are constrained by institutions and who deployed and are influenced by ideas.
We argue that three groups of actors could be argued to be essential for understanding the energy sector, and therefore for explaining an induced energy transition; *energy providers*, *policy makers* and *users of energy* (e.g. Scrase and Smith 2009: 710). The relationships between these groups of actors produce the institutions that govern the energy system in any particular country, and it is changes in the relationships that produce changes in governance. These institutions, including energy markets, ultimately determine practices, such as investment, technological change and outcomes relevant for eco-systems such as greenhouse gas emissions, all of which will have

further feedback effects on actors (Figure 3; see also Figure 1 in Hughes et al 2012). We now consider each of these relationships in turn.

In most countries, at the start of an energy transition, energy production, supply and investments will be dominated by *incumbent energy firms.*[13] There may be some exceptions (Denmark provides an example), but in most cases incumbents will be large private sector companies. At one level it is reasonable to think of such companies as primarily motivated by the anticipation of profit, adjusted for risk. However, energy incumbents may also be differentiated by how long- or short-term a view they take on profits, which in turn will depend on their corporate governance, their access to finance, their relationship with other firms and their degree of engagement with social goals. Once incumbents make investments in particular technologies, these investments will tend to shape both the subsequent actions of incumbents in energy markets and their vested interests. This is particularly so in the energy sector because infrastructures are so long-lived, and so give a heavily path-dependent nature to regimes and transitions.

Figure 3: Actors and agency in the energy system



[13] By energy firms we mean electricity generators, gas wholesalers and energy suppliers in retail markets, rather than upstream gas and oil companies, who play a more indirect role

The investment decisions of incumbents will be shaped heavily by institutions set by policy-makers (especially investments in new technologies). How innovative they are (i.e. how far they change their existing practices and investments) will therefore be heavily influenced by the exact configuration of incentives and regulations they are subject too. This configuration also includes the degree to which some or all of the energy system has been privatised (for example networks, or electricity system operator functions). Analyses such as Stenzel and Frenzel (2008) suggest that incumbents will respond positively to policies promoting particular technologies or activities if these present opportunities that fit within core corporate strategies and vested interests, but that they will tend to lobby against policies and regulations if not.

Incumbents may be able to shape policy through a range of means including direct lobbying, secondments to government, and sitting on technical committees that shape markets. Because large energy corporations have become central to the delivery of energy goods and services, they have also become the main conduit through which energy policy can be enacted. Their political power arises from the fact that politicians fear the response of voters to the possibility of the lights going out.[14] In this context a common strategy of large incumbents is to threaten such a possibility through investment strikes (Jessop 1990) or exit (i.e. divestment) as fall-back positions. As a result, large energy companies have enjoyed a high degree of influence, and 'maintaining business confidence and conditions become key state concerns' (Meadowcroft 2005: 492). Rational choice analyses argue that a key objective for incumbents in influencing regulation and policy will be to maintain high costs of and barriers to entry in markets (e.g. Stigler 1971).[15] How successful they are in this will determine how far *new entrants* can gain access to energy markets. New entrants can often be low-carbon and sustainable energy innovators. The relative power of incumbents and new entrants to protect or disrupt markets and slow or speed transition depends partly on the degree to which each camp is united or splintered. Splintering amongst innovators (as, for example, in the UK renewables industry) tends to preserve the status quo (Kretschmer 2008, Farrell and Klemperer 2007).

In setting policy, *politicians* are likely to be influenced by a range of factors. Some arise out the relationship with dominant actors in the energy industry as described above. Others, however, arise out of the relationship politicians have with *energy users*, especially *households*, which are also voters (*regulators* also typically have consumer interests written into the core of their remit).[16] In most countries, policy since the 1980s has sought to depoliticise the energy system, so that at the beginning of the transition there are likely to typically be low levels of interest in energy (Devine-Wright 2006, Kuzemko 2011: 64-65). There will be some variation between countries in how far the public (and business as energy users) are concerned about climate change and want to see change towards low-carbon energy. How far these concerns influence policymakers will depend in part on opportunities for coordination through electoral institutions (especially how far environmentalist parties are represented in and have leverage over governments) and civil society organisations.

[14] Firms in the energy supply chain are also important in that they provide technological innovation and employment, which gives them a degree of political power.

[15] In the UK, technical codes such as CUSC and BSC effectively impose large costs of participation in electricity wholesale markets, for example.

[16] *Civil servants* can also have an influence on energy policy making, because siloing in government often prevents effective coordination of policy across departments.

To the extent that environmental issues, especially climate change, are salient for energy users, policy makers are therefore likely to pay some attention to system outcomes such as changes in GHG emissions, above and beyond any concerns that they have directly through their understanding of climate science. However, the salience of these issues for households is often low relative to the perceived cost of energy services and concerns about energy security, and there is often limited willingness to pay for low-carbon energy (Harrison and Sundstrom 2010, Lockwood 2013, Carter 2008). As a result, policy makers will also be concerned about the costs of policy, and indeed this may dominate their approach to shaping institutions. *Business* as an *energy user* is also politically important, both because it employs voters and can also threaten exit (i.e. relocation abroad). Large energy-intensive users tend to lobby strongly against policies that increase energy costs. However, other businesses may support transitions because they see opportunities for revenue in low-carbon products and services and in owning renewable energy assets. Business leaders are also influenced by ideas about climate change and may try to adopt long term strategies that sacrifice short term profits for corporate image and action ahead of expected regulation. The resulting balance of views and interests in national business organisations determines the view of "business".

As discussed in section 4 above, in addition to political or electoral interests, we can also expect policy making actors to be influenced by ideas. Here the key issue is how narratives about environmental imperatives for reform in the energy sector (like climate change) interact with dominant *policy paradigms*. We might expect such framing sets of ideas to influence all actors, but policy makers most profoundly. As noted in section 5 above, the main shift in paradigms since the 1980s has been towards neo-liberal economic principles, although the degree to which this has happened has varied between countries (Hay 2007, Blyth 2002, Schmidt and Radaelli 2004). Current articulations by governments of the need to transition energy systems towards a sustainable future can be understood as part of a wider struggle to find the 'best story' to fit the socio-political context. Current framings of energy as a policy area are related to security, climate, poverty and economic arguments (Kuzemko 2013) – and each will find a different degree of support from different groups including publics. Power becomes a question of successfully framing and representing problems in order to downplay other, potentially viable, alternative interpretive frameworks and solutions (Smith et al 2005).[17] The 'best story' ultimately is the one that finds sufficient political, commercial and public purchase such that political changes can be enabled – often in times of crisis (see Hay 1996). This is important in that reasons accepted for change tend then to drive the direction of new policies adopted. For example, the recent reframing of energy as a security issue in the UK, and elsewhere, has produced policies aimed at encouraging 'home grown' energy production which has, in turn, been a boost for nuclear energy in some countries (Kuzemko 2013). The ways in which problems are framed and the solutions adopted in response are also, however, coloured by existing political and corporate institutions (cf. Hall 1993; Blyth 2002).

Overall, we can see much of the process by which policy makers shape the institutions that govern the energy system in most countries as a balancing of the perceived interests of energy users with those of energy provider incumbents (cf. Peltzman 1976), influenced by concerns about climate change and energy, all within the context of the dominant economic policy paradigm and other, competing ideas about energy.

[17] Frames: ideas as concepts that help policymakers to legitimise policy solutions to the public (Campbell 1998: 385)

Actors in the energy system thus shape the evolution of institutions through their interactions. However, they do so not from a blank sheet, but rather, (drawing on the approach of historical institutionalism, and echoing the socio-technical and evolutionary economics literatures), under conditions of path-dependency and constraints imposed by existing technologies, institutions and vested interests (Lovio et al). These effects can be long-lasting in the energy sector because energy infrastructures can be expensive and very long-lived.

Such path-dependence can be created both at the technology level, and at the overall fuel level by patterns of geology and geography by which fossil fuel energy resources have been distributed (Hadfield 2008), and the temporal factors by which they have been discovered in particular countries. Easy access to large indigenous fossil fuel resources, historically considered strategic assets, has meant that production and use of those particular resources has become deeply embedded within some national, and sub-national, political economies, with consequent effects on policy. For example, at the time of the energy crises of the 1970s and 1980s, Denmark, lacking its own indigenous resources at that time, responded with an aggressive drive to improve efficiency (partly through district heating and CHP) as well as pursing wind power, while the UK with its recently discovered North Sea oil and gas finds, continued with centralised electricity generation and developed a natural gas network and individual boilers with little emphasis on efficiency. This now puts these two countries in different starting points in attempting a low-carbon energy transition. Another such factor is the historical role and status of civil nuclear power. Those countries which had a geo-political interest in the military use of nuclear power after WWII tended to develop a civil nuclear resource, while those that did, or could not, have tended to have limited or no civil nuclear programmes.

6.3 Conditions for transition

Based on this characterisation of energy systems, we can identify certain conditions that make a sustainable energy transition more or less likely, associated with the key interactions described above. A first, basic condition is to do with the basic nature of energy investments. As we argued in section 2 above, for outcomes and practices of actors in energy system (especially private sector commercial actors) to change in the direction of sustainable energy, new practices will have to be less costly, or more profitable (taking into account any public policy support mechanisms), than existing ones. At the same time, the risks of such practices and outcomes, including policy and political risk, will have to be mitigated sufficiently. *Overall profits, adjusted for risk, will have to be greater than those that can be achieved elsewhere, and will have to fit with the required timescales of investors, including shareholders or other stakeholders*.

A second condition relates to the nature of institutional arrangements in energy markets, whether in wholesale production or in retailing. We argue that *institutional arrangements which are more inclusive of a wide range of entrants are more conducive to innovation in practices and outcomes than those which are exclusive* (Mitchell 2008). The inclusivity or exclusivity of markets can be expected to relate partly to the power of incumbents.

Relevant especially for policy-makers, a third condition is that successful delivery of sustainable practices and outcomes depends on *opportunities for risk-adjusted returns being sufficient to attract investors, but at the same time not being so high as to impose*

unacceptable costs on different energy user groups. This applies not only to situations where energy producers are large incumbent firms, but also to situations where large numbers of actors, including private households, make sustainable energy investments, as controversy over solar FiTs across Europe shows.

A related fourth condition is that *policies designed to move the energy system in the direction of sustainability have to be self-reinforcing in order to be successful*; as noted above, such policies must realise increasing returns or spill-overs not only economically (for example reducing the costs of sustainable technologies as they are expanded) but also politically (for example by creating new interest groups or institutions that lock in reforms).

There are also two conditions relating to the background factors in our account. We have argued that knowledge of climate change is a background factor for all actors, and a potential driver of change. However, how strong a driver it is depends heavily on how the climate crisis is framed and how far it has resonance with stakeholders. *The more that climate change is perceived as a crisis the more likely it is that major transformations in the energy system can be brought about*. In practice, in most contexts climate change is seen as a long-term problem, whose effects are uncertain and diffuse, which is why nearer term issues such as energy security and prices are typically more salient for the majority of people. The perceptions of households are key here, since they form a constraint on political actors, and households will in most cases have to bear the costs of transition too.

The other issue is the nature of the dominant policy paradigm(s). We argue that policies that support new practices and outcomes for a sustainable future are more likely *if the dominant policy paradigm is consistent with, and gives strong value to, sustainability*.

Consider how the alignment of such conditions might lead to the emergence of a successful sustainable energy transition through the interactions we outline above. Initially, all actors (government, energy producers and users) are aware of climate change science and enough of the public are concerned to create sufficient political space for action. Politicians are strongly motivated to act, both because of public opinion and their own awareness of the climate imperative. The dominant policy paradigm is either supportive of policies for sustainable energy, or if not is not sufficiently strongly entrenched amongst civil servants and the regulator to block action. The government gives effective support to investment in sustainable energy technologies that is sufficient, once adjusted for risk, to give a strong return on investment, while not so high in cost that it alienates energy users. The salience of sustainability amongst households and business leaders is sufficiently high to offset concerns about costs, or income is high enough to make costs less material. At the same time, policy makers are willing to overcome any opposition from incumbents where they have vested interests opposed to new policy, or restructure ownership to break up incumbent power. Markets in energy wholesaling and retailing are sufficiently open to allow innovators to enter, or are opened up by government. The owners of networks give investors in low-carbon technologies equal or preferential access (or are required or incentivised to do so by government). Energy resource lobbies are not effective in stopping (gas, oil, coal) or skewing (nuclear) such policies. Households and businesses themselves may invest in new technologies, along with incumbents and new entrant firms. New vested interests in sustainable energy are formed, helping to create increasing political returns. Supply chain employment also offsets political concerns about costs. Costs of new technologies and services come down quickly with increasing

economic returns and so limit policy costs. Energy users increase political support for the transition, which strengthens the position of politicians in relation to incumbents and unsustainable energy resource lobbies. Policies are strengthened for technology support, network reconfiguration and energy services markets, and the rate of investment in new technologies and services increases. The positive feedback cycle continues until the transition is complete.

Such a scenario is not completely unrealistic (Germany, for example, may be following something like this pathway), but it does show how many things have to go right for a transition not only to begin but then be sustained and accelerate. The degree to which this alignment of factors is present varies, which is why we would not expect to see induced sustainable energy transitions happening at the same speed and in the same way everywhere. Such differences raise the questions of how the interactions between actors are likely to vary between settings, and why.

7. A framework for the comparative analysis of sustainable energy transitions

Thus far we have argued that in understanding why different countries are undergoing sustainable energy transitions at different speeds and in different ways, the widely used socio-technical transitions approach suffers from a lack of political analysis and of a comparative explanatory framework. Instead, we have suggested that a more useful approach will be to build on the varieties or models of capitalism approaches that provide explanations of economic outcomes in terms of differences in institutions and discourse. In particular, we suggest that the striking differences in the speed of energy transitions in the UK vs. Germany and Denmark may be related to the contrast between the former's liberal market institutions and neo-liberal policy paradigm and the more managed markets and social market policy discourses in the latter.

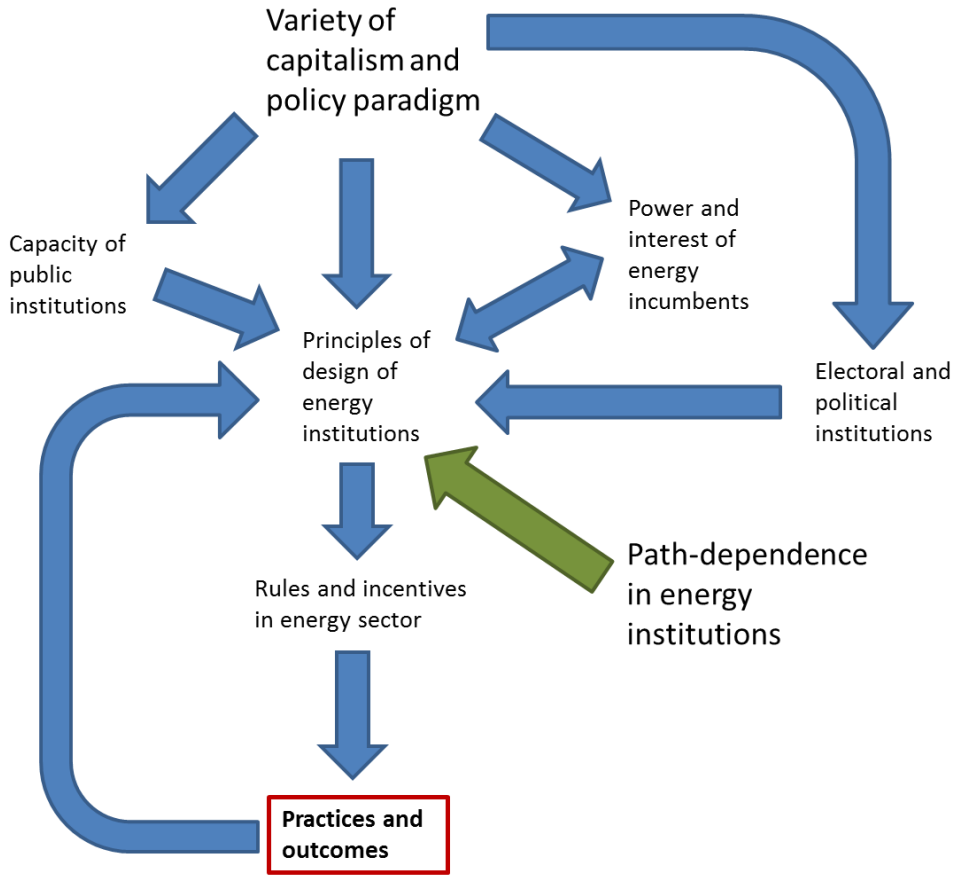
We have noted that advanced capitalist economies share many common features. With a few exceptions, almost all have historically been fossil fuel-dependent with a high degree of carbon lock-in. All have an energy market with at least some incumbent private companies and a regulator. All have publics who are concerned about climate change and other environmental issues to a varying extent, but also about energy costs. All have political leaders who face regular elections.

However, there are also some key differences that our approach implies will explain much of the variation in outcomes, based on our analysis of the nature of interactions and conditions for sustainable energy transition (see Figure 4).

First, we argue that the *speed of energy transition* in any specific setting is likely to depend on the nature of the *dominant policy paradigm and related economic institutions*. In particular, we argue that countries that have embraced a *neo-liberal policy paradigm* more thoroughly and have more *market-based economic institutions* are likely to make the transition to a low carbon energy system *more slowly*. We suggest that there are four broad routes through which this relationship might work: the direct influence of dominant policy paradigms on policy and institutional design; effects that work via the capacity of public institutions; effects via market structure and the resulting power and incentives of incumbents, and effects via political and electoral

institutions. Second, we argue that historical path-dependencies relating to *inertia in institutions specific to the energy sector* in each country will also influence the *path of the transition*. We examine each of these arguments in turn below.

Figure 4: Framework for the comparative analysis of energy transitions



7.1 Role of policy paradigms and institutions

Countries in which an neo-liberal economic policy paradigm has been most strongly embraced are likely to be slower in making a transition to a sustainable energy system because of the direct influence of that paradigm on the principles of institutional and policy design:

- Policy makers working with strong adherence to in a neo-liberal paradigm have an ideological commitment to particular policies over a more pragmatic approach to sustainable energy (Kuzemko 2013b, Kern and Mitchell 2010). This can increase policy costs, for example as has been the case with technology support policies in the UK compared with Germany or Denmark (OPTRES 2007), and has led to uncertainty and delay (Gross and Heptonstall 2010).
- More widely, the stronger the neo-liberal paradigm, the more that short-term financial costs dominate decision making and the more difficult it is for climate change and other environmental ideas to influence policy. In the UK, the addition of climate objectives has arguably changed the function of energy policy, these

have been framed in such a way that they do not undermine the basic structures of the neoliberal economic policy paradigm (Bernstein 2002). Despite new knowledge about climate change, 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. This approach to energy policy has not been seriously challenged by public opinion in the UK, as support for climate change mitigation has not been a significant part of the political landscape.

- At the same time, as the neo-liberal market-based paradigm calls for policy making based on marginalist principles, it is more difficult for government to provide strong and clear coordination of the non-marginal change needed to escape lock-in. Not all technologies are compatible, and choosing pathways involve making long-term decisions. Regulatory institutions and rules designed for minimising costs are less likely not be fit for the purpose of managing energy transition. Incentive regulation designed for such purposes has been in place for longer, and in stronger forms, in the UK compared with other European countries (Thatcher 2007).

Second, the neo-liberal paradigm (and indeed its related wider political project) has led to a hollowing out of public institutions (Marquand 2004) with consequences for a managed energy transition:

- Managed energy transition requires expert, up-to-date knowledge about energy systems, technologies, and infrastructures, as well as about how to formulate effective public and social policy. However, a more thorough privatisation and adoption of a neo-liberal policy paradigm leads to more hollowing out of energy knowledge and technical capacity within government, reducing the ability of government to make good energy policy, and increasing dependence on secondments from incumbents. This has been a particularly acute problem in the UK (Helm 2003; Tutton 2010; Kuzemko 2013) where the original Department of Energy was dismantled after privatisation, with responsibility for policy being passed to a sub-division of the DTI with had no direct energy related mandates and which over time encouraged generalised economic approaches over *energy specific* knowledge (Kuzemko 2013: various).
- At the same time, we posit that the more thorough the adoption of a neo-liberal policy paradigm, the lower the willingness of government to invest in and support networks of public and private technological innovation actors (e.g. universities, tech companies, development banks) in energy innovation. In Germany, the maintenance of institutions such as the KfW bank, which offers cheap finance to sustainable projects, and the adoption of command-and-control policies have helped to establish new industries around emergent technologies (cf. Meadowcroft 2011; Mitchell 2008).

Third, while in principle the privatisation and liberalisation of energy opens up possibilities for greater competition and radical innovation (Markard and Truffer 2006), in practice, “the new institutional context applies criteria and imposes requirements that still favour established players, non-disruptive technologies and existing patterns of material infrastructure.” (Srcase and Smith 2009: 711):

- Where energy networks and the system operator function in electricity are owned by private firms that have to bear the uncertainty or costs of adapting network operation this can creates an incentive that works against investment in low

carbon technologies that are disruptive for current network and system operation (e.g. Stenzel and Frenzel 2008).

- Corporate governance in liberal market economies with strong adherence to a neo-liberal policy paradigm is more likely to be dominated by dispersed share ownership, with pressure for short-term returns and an absence of other stakeholder influence (Schmidt 2002). This arrangement militates against energy firms from taking longer-term views on profits and on low carbon transition. The UK in particular has a distinctive history of corporate governance giving a high degree of autonomy to shareholders (Moran 2003: 96-100). By contrast, in coordinated market economies, firms have greater access to more patient finance, but are also typically governed by boards with representation from a range of interest groups, including employees and other firms in the value chain.
- Sunk costs and economies of scale in the energy sector mean that there are significant barriers to entry, so that privatisation and liberalisation has paradoxically led to high levels of market concentration, which can lead to less innovation (Gilbert 2006). Where divestment has been less thorough, energy producers and suppliers owned by the central state, municipalities or communities still exist. These countries tend to have a wider range of actors and drivers of action, and as a result see both more innovation and the maintenance of a market that is more open to new entrants. This wider process helps underpin the political sustainability of policy (Patashnik 2008) because it is more likely to give households and businesses a stake in low carbon energy assets.[18]
- In completely privatised sectors, a small number of private firms are in a strong position to coordinate to shape regulatory institutions so that they institutions further reinforce barriers to entry.
- The larger the share of system owned by a few large incumbents, the more vulnerable the government is to threats of investment strikes. Also, the larger the share privatised, the higher the proportion of the energy system that is potentially owned by foreign-based companies, which makes the threat of exit via divestment more credible.[19]

Fourth, electoral and political institutions associated with coordinated or managed capitalism tend to produce political conditions that are more conducive to a managed energy transition, above and beyond any underlying differences in how 'green' public opinion is in different countries:

- Most countries with coordinated market economies such as Denmark and Germany have proportional representation electoral systems, whereas those like the UK with liberal market economies retained majoritarian systems (Cusack et al 2007).[20] Majoritarian electoral systems work against smaller parties, including the Green parties, by comparison with proportional representation (PR) systems. There is a strong correlation between electoral systems and environmental policy (Scruggs 1999).

[18] This is evident in the case of onshore wind, where projects in the UK owned by incumbents or large developers are vulnerable to local opposition, whereas projects in Germany and Denmark are largely owned by smaller individuals, cooperatives and other local actors and face much less opposition (Szarka 2006).

[19] The UK industry has a high share of foreign ownership, which increases the credibility of threats of exit, which indeed are quite frequent.

[20] Interestingly, the devolved regions of Scotland and Wales have recently adopted electoral systems that have elements of PR, and the former at least has a more committed approach to policy areas such as renewable energy.

- At the same time, countries with managed capitalism and PR systems also have less inequality (Crepaz 1998) and higher levels of welfare provision (Iversen and Soskice 2006, Austen-Smith 2000). In liberal market economies over the last 15 years, real wages have grown less, with a greater share of national income going to capital, and welfare settlements have been less generous. Consequently, inequality has increased dramatically, there is greater poverty at the lower end and real incomes have been squeezed in the middle. These effects make it politically more difficult to manage the costs of energy transition policy on energy bills. In the UK the debate on fuel poverty is more prominent than in Germany or Denmark.
- A final point is that the approach to problems that difficult to deal with within short-term political cycles within neo-liberal thinking is to depoliticise them through delegation (Kuzemko 2011: 61, Hay 2007). However, depoliticisation can never be complete, and tends to collapse in crises or transitions (for monetary policy see Posen 1993; for rail regulation see Moran 2003: 115-19; for climate policy see Lockwood 2013b;). In countries where the neo-liberal policy paradigm has not been embraced so strongly, policy makers are more likely to seek to lock in reforms through increasing political returns, a strategy is more likely to succeed in the face of crisis or political challenge (Patashnik 2008).

7.2 Role of historical path-dependency

As outlined in section 6 above, energy systems are path dependent, and can be strongly affected past events related to geography and geology (such as the presence of coal or oil reserves in a country), or history (notably how far a country has embraced military and therefore civil nuclear power). Path-dependencies in energy systems are not decisive in themselves, but are transmitted through political decision and the political power of the resulting lobbies that arise. Once entrenched in the political dynamic, however, such factors can be significant, especially in the shape of the pathways that energy transitions take.

Countries with strong fossil fuel resource lobbies are likely to see energy transition resisted and slowed. In the transport energy sector the obvious lobby is oil. In energy sectors, the key lobbies are coal and gas (usually also part of the oil lobby). Coal is often a particularly strong lobby because it creates more employment than oil (Mitchell 2011). In Germany and Denmark the coal (including lignite) lobby is still strong and underpins the persistence of coal in the energy mix despite the strong push towards a more sustainable system. In the UK, by comparison, the decline of the coal industry over the last half century (Turnheim and Geels 2012) culminating in the 1984-85 miners' strike, made it easier for the British Government to ban new coal-fired power plants in early 2009. However, the UK does have a strong gas lobby because of the history of North Sea production, which is now a major factor in the speed of movement towards a sustainable energy transition.

Countries with a military nuclear history have tended to inherit a nuclear lobby with considerable political power. In the UK and France, the commitment to an independent nuclear deterrent after the Second World War gave nuclear technology high status, and a wave of investments was made in the 1960s and 70s. The nuclear lobby has shown an ability to re-invent itself, most recently through its low carbon credentials, as well as energy supply security aspects, and its political power has persisted, albeit diminished from time to time, ever since. By contrast, Germany was forbidden from developing a nuclear military capacity after the War, and Denmark was too small a geo-political actor

to have such an ambition. Both actually felt threatened by the Cold War nuclear arms race, and in both countries strong anti-nuclear movements developed, which have in turn shaped their energy policies. A nuclear lobby does not so much stop or slow a sustainable energy transition as distort it, by seeking to capture the resources available for low carbon energy support and potentially crowding out the realisation of learning economies for renewables (e.g. Kalkuhl et al 2012). The two technology families are not particularly compatible (e.g. Verbruggen 2008) and once one is established, technology-specific complementarities with grid infrastructure are likely to crowd out the other family (Katz and Shapiro 1985: 424-25).

These legacies of history and geography not only shape attitudes towards transition now but have shaped the responses of different countries to energy shocks or crises in the past, for example in the 1970s and early 1980s, in different ways. As noted, the UK had just discovered oil and gas in the North Sea and so did not invest heavily in energy efficiency. It continued with a nuclear power programme, and increasingly with gas given fast growing North Sea production. In the US, oil import dependency was moving in the other direction, and major efforts to improve energy efficiency were made, with California undertaking major institutional reforms in energy retailing (decoupling). But as in the UK, the nuclear programme continued. In Continental Europe the response was typically different. Most countries had no oil or gas reserves and so, at a time when pricing of these products had undergone serious political shocks, they took steps to improve energy efficiency, Denmark most dramatically by embracing decentralised combined heat and power. At the same time, strong anti-nuclear movements in many countries prevented (Denmark) or limited (Germany) the development of nuclear power as an alternative to oil in power generation.

8. Conclusion

This paper has sought to develop a framework for understanding why Britain has made such slow progress along a soft energy path compared to other countries, especially those in continental north-western Europe. The dominant approach to energy transitions, the socio-technical transition framework provides useful insights, but along with related analyses, does not have a good account of the politics of change that lies at the heart of transitions, and at the same time, lacks the explanatory power to explain comparative divergence in experience. We propose an alternative approach, rooted in institutionalist theories in political science, and especially the varieties or models of capitalism school of comparative institutionalist political economy. Applied to an analysis of the key actors and interactions in the energy sector, we generate a number of arguments that cast light on Britain's relatively poor record on sustainable energy transition.

Our main argument is that differences in speed of change towards sustainable energy system between countries are related to the depth of market liberal paradigm and associated economic and political institutional differences; specifically, the UK as a liberal market economy with a strong neo-liberal policy paradigm is likely to make the transition more slowly than 'coordinated' or 'managed' economies such as Germany or Denmark. A further implication is that where neo-liberal policy paradigms have strengthened or weakened, transition might be expected to slow or speed up accordingly (the election of a more market-oriented government in Denmark in 2000 led to changes in support policies and significantly slowed the expansion of wind power –

see Mendonça et al 2009). We argue that the effects of paradigms and institutional differences work through a number of different routes, including the direct influence of the policy paradigm on policy and institutional design; effects that work through the capacity of public institutions; effects that work via market structure and the resulting power and incentives of incumbents, and effects that work through electoral and political institutions. In addition, we also see progress in energy transitions as influenced and shaped by path-dependence in the form of inertia in institutions specific to the energy sector, especially the influence of particular fossil-fuel and nuclear lobbies.

The argument that a neo-liberal economic policy paradigm has heavily influenced decisions in relation to the energy transition in the UK, severely limiting policy choices and outcomes through the central idea that the role of government in the energy sector should be minimised, is not new and has been made by others (cf. Jacobs 1991; Bernstein 2002; Meadowcroft 2005; Carter 2007, Mitchell 2008, Keay 2010, Rutledge and Wright 2010). However, here we have developed a theoretical framework allowing a more systematic and comparative analysis, generating a number of testable hypotheses.

The main implication of this approach for the UK is that major institutional change may be needed if a sustainable energy transition is to be accelerated. Views vary on how feasible it is to transplant institutional designs effectively across different systems (e.g. Soskice 1997; Culpepper 2001; Rodrik 2007). However, it is clear that current institutions formed under the influence of neo-liberal ideas across a number of areas in the UK, including finance, media, transport and health, are now unstable and in crisis, and energy is no exception. Whether the UK can make a sustainable energy transition on the basis of liberal market policies is now widely debated in the policy community (e.g. Tutton 2009, Keays et al 2012). It is in fact very likely that a new policy paradigm will emerge in the next few years, with implications for the wider economy as well as the energy sector. Whether such a new paradigm will have the characteristics needed to accelerate a sustainable energy transition in Britain remains to be seen, but it is only through frameworks such as the one put forward here that we can anticipate what those characteristics are.

References

Acemoglu, D., Johnson, S. and Robinson, J. (2005) “Institutions as the fundamental cause of long-run growth” in P. Aghion and S. Durlauf (eds.) *Handbook of Economic Growth* Elsevier

Austen-Smith, D. (2000) “Redistributing income under Proportional Representation.” *Journal of Political Economy* 108: 1235–69.

Berger, S. and Dore, R. (1996) *National Diversity and Global Capitalism* (Ithaca and London: Cornell University Press)

Berkhout, F., Smith, A. and Stirling, A. (2004) ‘Socio-technical regimes and transition contexts’ in Elzen, B., Geels, F. and Green, K. (eds.) *System Innovation and the Transition to Sustainability: Theory, Evidence and Policy* (Cheltenham: Edward Elgar), pp. 48-??

Bhattacharya, S. (2011) *Energy Economics: Concepts, Issues, Markets and Governance* (Springer:)

Blyth, M. (1997) “Any more bright ideas? The ideational turn of comparative political economy” *Comparative Politics* 29/2

Campbell, J. L. (1998) “Institutional analysis and the role of ideas in political economy” *Theory and Society* 27, 3: 377-409

Campbell, J. L. (2002) “Ideas, politics and public policy” *Annual Review of Sociology* 28: 1, 21-38

Campbell, J. L. (2007) “Challenges for institutional theory: a response to Crouch, Streeck and Whitley” *Socio-Economic Review* 5: 527-67

Caniëls, M. C. J. and Romijn, H. A. (2008) ‘Strategic niche management: towards a policy tool for sustainable development’ *Technology Analysis and Strategic Management* 20: 2, 245-66

Crepaz, Markus. 1998. “Inclusion versus exclusion - Political institutions and welfare expenditures” *Comparative Politics* 31 (1): 61–80

Crouch, C. (2005a) *Capitalist Diversity and Change: Recombinant Governance and Institutional Entrepreneurs*

Crouch, C. (2005b) ‘Models of capitalism’ *New Political Economy*, 10: 4, pp 439-56

Crouch, C. and Streeck, W. (1997) eds *Political Economy of Modern Capitalism: Mapping Convergence and Diversity* (London: Sage)

Cusack, T., Iversen, T. and Soskice, D. (2007) “Economic interests and the origins of electoral systems” *American Political Science Review* 101, 3: 373-91

Dore, R., Lazonick, W. and O’Sullivan, M. (1999), ‘Varieties of Capitalism in the Twentieth Century’, *Oxford Review of Economic Policy*, 15 (4), pp. 102–20.

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

Foxon, T. J. (2011) A coevolutionary framework for analysing a transition to a sustainable low carbon economy’, *Ecological Economics* 70 (2011), pp. 2258-2267.

Geels, F.W. (2002) 'Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study' *Research Policy* 31: 8/9, 1257–1274.

Geels, F. (2004) 'From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory' *Research Policy* 33: 6-7, 897-920

Geels (2010) 'Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective' *Research Policy* 39, 495-510

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

Gilbert, R. (2006) "Looking for Mr. Schumpeter: Where are we in the competition-innovation debate?" in A. Jaffe, J. Lerner and S. Stern (eds.) *Innovation Policy and the Economy* NBER

Gross, R. and Heptonstall, P. (2010) 'Liberalised energy markets: an obstacle to renewables?' in I. Rutledge and P. Wright (eds.) *UK Energy Policy and the End of Market Fundamentalism* Oxford: O.U.P.

Hall, P.A. (2007), 'The Evolution of Varieties of Capitalism in Europe', in B. Hancke, M. Rhodes and M. Thatcher (eds.), *Beyond Varieties of Capitalism: Contradictions, Complementarities and Change* (Oxford: Oxford University Press).

Hall, P. A. (ed.) (1989) *The Political Power of Economic Ideas: Keynesianism Across Nations.* Princeton, N.J.: Princeton University Press.

Hall, P.A. and Gingerich, D.W. (2009), 'Varieties of Capitalism and Institutional Complementarities in the Political Economy', *British Journal of Political Science*, 39 (3), pp. 449–82.

Hall, P.A. and Soskice, D. (2001) *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage* Oxford: O.U.P.

Hall, P.A. and Soskice, D. (2003), 'Varieties of Capitalism and Institutional Change: A Response to Three Critics', *Comparative European Politics*, 1 (2), pp. 241–50.

Hall, P. A. and Taylor, R. C. R. (1996) 'Political science and the three "new" institutionalisms' *Political Studies*, 44, 936-57

Hall, P.A. and Thelen, K. (2009), 'Institutional Change in Varieties of Capitalism', *Socio-economic Review*, 7 (1), pp. 7–34

Hancke, B. (2009) *Debating Varieties of Capitalism: A Reader* (Oxford: Oxford University Press).

Hughes, N., Strachan. N,. and Gross, R. (2012) 'The structure of uncertainty in future low carbon pathways' *Energy Policy* 52 (10), pp. 45-54

Iversen, T. and Soskice, D. (2006) "Electoral institutions and the politics of coalitions: why some democracies redistribute more than others" American Political Science Review 100, 2: 165-181

Jacobsen, J. K. (1995) "Much ado about ideas: the cognitive factor in economic policy" *World Politics* 47: 283-310

Keay, M. (2010) 'Can the market deliver security and environmental protection in electricity generation' in I. Rutledge and P. Wright (eds.) *UK Energy Policy and the End of Market Fundamentalism* Oxford: O.U.P.

Keay, M., Rhys, J. and Robinson, D. (2012) *Decarbonization of the electricity industry – is there still a place for markets?* Working Paper EL9, Oxford Institute for Energy Studies. Available at: http://www.oxfordenergy.org/wpcms/wp-content/uploads/2012/11/EL-9.pdf

Kemp, R. (1994) 'Technology and the transition to environmental sustainability: the problem of technological regime shifts'. *Futures* 26, 1023–1046.

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.

Kemp, R., Rip, A., Schot, J.W., 2001. Constructing transition paths through the management of niches. In: Garud, R., Karnoe,P. (Eds.), Path Dependence and Creation. Lawrence Erlbaum,Mahwah, NJ, pp. 269–299.

Kemp, R. and Loorbach, D., 2003. Governance for sustainable development through Transition Management. Paper presented to the Berlin Conference on the Human Dimensions of Global Environmental Change, 5–6 December.

Kemp, R., Loorbach, D., 2006. Transition management: a reflexive governance approach. In: Voß, J.-P., Bauknecht, D., Kemp, R. (Eds.), Reflexive Governance for Sustainable Development. Edward Elgar, Cheltenham, pp. 103–130.

Kemp et al (2007) 'Assessing the Dutch Energy Transition Policy: How does it Deal with Dilemmas of Managing Transitions', *Environmental Policy and Planning* 9, 3, 315-33

Kern, F. (2011) 'Ideas, institutions and interests: explaining policy divergence in fostering "system innovations" towards sustainability' *Environment and Planning C: Government and Policy*, 29 (6).

Kern, F. and Howlett, M. (2009) 'Implementing transition management as policy reforms: a case study of the Dutch energy sector' *Policy Sciences*, 42 (4). pp. 391-408

Kern, F.; Kuzemko, C. and Mitchell, C. (2014 forthcoming) 'Measuring and Explaining Policy Paradigms Change: The Case of UK Energy Policy', *Policy & Politics*.

Kern, F. and Smith, A. (2009) 'Restructuring energy systems for sustainability? Energy transition policy in the Netherlands' *Energy Policy*, 36 (11). pp. 4093-4103.

Kuzemko, C. (2013a) *Problematising Governance for Low Carbon Transition* IGov Working Paper 1, Energy Policy Group, University of Exeter.

Kuzemko, C. (2013b) *The Energy Security-Climate Nexus: Institutional Change in the UK and Beyond*. Basingstoke and New York: Palgrave Macmillan.

Loorbach, D., 2010. Transition management for sustainable development: a prescriptive, complexity-based governance framework. Governance 23, 161–183.

Lovio, R., Mickwitz, P. and Heiskanen (2011) 'Path dependence, path creation and creative destruction in the evolution of energy systems' in R. Wüstenhagen and R. Wuebker (eds.) *Handbook of research on energy entrepreneurship* Edward Elgar, pp. 274-301,

Malerba, F. (2006) 'Innovation and the evolution of industries', *Journal of Evolutionary Economics* 16 (1), 3–23.

Markard, J. and Truffer, B. (2006) 'Innovation processes in large technical systems: market liberalization as a driver for radical change?' *Research Policy* 35, 5: 609-25

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

Marquand, D. (2004) *Decline of the Public: The Hollowing Out of Citizenship*, London, Polity Press

Meadowcroft, J. (2005) 'Environmental political economy, technological transitions and the state' *New Political Economy* 10: 4, 479-98

Meadowcroft, J. (2009) 'What about the politics? Sustainable development, transition management and long term energy transitions' *Policy Sciences* 42: 323-340

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

Mendonça, M., Lacey, S. and Hvelplund (2009) 'Stability, participation and transparency in renewable energy policy: Lessons from Denmark and the United States' *Policy and Society* 27: 379-98

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

Mitchell, C. (2000) 'Neutral regulation – the vital ingredient for a sustainable energy future' *Energy and Environment* 11, 377-88

Mitchell, C. (2002) 'System change – drivers and requirements for a sustainable energy policy' Unpublished paper, Warwick Business School

Mitchell, T. (2011) *Carbon Democracy: Political Power in the Age of Oil.* London and Brooklyn: Verso.

Moran, M. (2003) *The British Regulatory State: High Modernism and Hyper-Innovation* (Oxford: Oxford University Press)

Nelson, R. (2007) *Economic development from the perspective of evolutionary economic theory* Working Paper 2007-02, Global Network for Economics of Learning, Innovation and Competence Building (GLOBELICS), Available on-line at: http://dcsh.xoc.uam.mx/eii/globelicswp/wpg0702.pdf

Nelson, R. and Winter, S. (1982) *An Evoilutionary Thoery of Ecopnomic Change* Cambridge, MA: Bellknap Press

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

Raven, R.P.J.M., Verbong, G., 2007. Multi-regime interactions in the Dutch energy sector: the case of combined heat and power technologies in the Netherlands 1970–2000. *Technology Analysis & Strategic Management* 19 (4), 491–507.

Rip, A., Kemp, R., 1998. Technological change. In: Rayner, S., Malone, E.L. (Eds), Human Choice and Climate Change, vol. 2. Battelle Press, Columbus, OH, pp. 327–399.

Ritzer, G. and Stepnisky, J. (2013) *Sociological Theory* 9th Edition, McGraw Hill

Rotmans, J., Kemp, R. and van Asselt, M. (2001) 'More evolution than revolution: transition management in public policy' *Foresight* 3: 1, 15-31

Rutledge, I. and Wright, P. (2010) (eds.) *UK Energy Policy and the End of Market Fundamentalism* Oxford: O.U.P.

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

Shove, E. and Walker, G. (2007) 'CAUTION! Transitions ahead: politics, practice and sustainable transition management' *Environment and Planning A*, 39, 763-70

Smith Adrian; Raven, Rob (2012) 'What is a protective space? Reconsidering niches in transitions to sustainability', *Research Policy* 41 (2012), 1025-1036.

Smith et al (2010) 'Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges' *Research Policy* 39: 4, 435-448

Soskice, D. (1997) "Stakeholding, yes. The German model, No." in G. Kelly et al (eds.) *Stakeholder Capitalism* London, Macmillan

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, pp. 2645-57

Steward, T. (2013) *Demand and decarbonisation in 2050: Themes from scenarios.* IGov Working Paper, Energy Policy Group, University of Exeter

Streeck, W. and Thelen, K. eds (2005) *Beyond Continuity: Institutional Change in Advanced Political Economies*

Streeck, W. and Thelen, K. (2009) 'Institutional change in advanced political economies' in B. Hancké ed. *Debating Varieties of Capitalism: A Reader* Oxford, O.U.P.

Thatcher, M. (2007) 'Reforming national regulatory institutions: the EU and cross-national variety in European network industries' in Hancké, B. Rhopdes, M. and Thatcher, M. (eds.) *Beyond Varieties of Capitalism: Conflict, contradiction and complementarities in the European economy* Oxford, O.U.P., pp. 147-72

Tutton, T. (2009) *The (potentially) topsy-turvy world of energy regulation: RPI-X@20 and Project Discovery* (Oxford: Oxera). Available at: http://www.oxera.com/Oxera/media/Oxera/downloads/Agenda/The-topsy-turvy-world-of-energy-regulation_1.pdf?ext=.pdf

Unruh, G. (2000) "Understanding carbon lock-in" *Energy Policy* 28: 817-830

Verbong, G. P. J. and Geels, F. W. (2010) 'Exploring sustainability transitions in the electricity sector with socio-technical pathways' *Technological Forecasting and Social Change* 77: 8, 1214-21

Wicksell, M. (2013) 'Accelerated energy innovation and its implications for innovation theory' Presentation at an IGov Workshop on Theorising Governance for a Sustainable Economy, London 30 April 2013, http://projects.exeter.ac.uk/igov/wp-content/uploads/2013/05/Winskel-M-Panel-2.pdf