The Importance of Governance for Innovation:

a Theory of Managed Energy Transition

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Introduction

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 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.

It starts from the observation that while a great deal has changed within certain countries' energy systems in terms of targets and aspirations, less has altered in terms of structural change and practical outcomes, although with considerable variation between countries. A cursory examination illuminates the important role of both energy system rules (in enabling or blocking change) and incentives (in making change economic or not). How and why rules and incentives are set as they are; and how and why they change; and to what effect make up a particular focus of interest.

The central, albeit provisional, hypothesis of this paper 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. Because of this, a critical precondition for more innovation in the UK is the implementation of an appropriate governance system. The paper argues that while different theories of transition 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 provisional theory of transition set out in this paper – Theory of Managed Energy Transition (TMET) - is 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 energy policy implementation and delivery and secondly, a focus on change in practice and outcomes.

Our approach rests on three main basic positions. The first is that the required timescales of transition to a sustainable energy future is unprecedented and needs to be managed. Secondly, within theories of transition the concept of agency[1] is underdeveloped in current approaches to innovation, and the same can be said of political institutions (and how they operate, alter and impact), the interaction between institutions (and their rules and incentives) and actors and their agency. The third is that the energy sector has particular qualities, referred to here as historic and geographic factors, which have to be taken into consideration when thinking of its transition.

Our provisional framework approaches the energy system as constructed by interactions between three groups of actors:

- policy makers (politicians, civil servants, regulators etc);
- energy providers (energy resource firms, such as oil and gas companies, incumbent energy firms, such as generators, suppliers; networks, new entrants; supply chain firms); and
- energy users (such as households and businesses);

[1] For example Foxon (2011) states 'key events in the transition to a sustainable low carbon economy may occur through technological changes, forming of institutions, revisions of business strategies or changes in user practices, and how these changes interact with changes in natural ecosystems. Each of these types of change involves a role for agency ie for actors to actively influence change, though the consequences of any individual action will always be uncertain, as it is mediated through the interaction with existing structures within the five systems." This process of influencing change is referred to as 'path creation' (Garrud and Karnoe, 2001; and Geels and Schot, 2008).

and as characterised by a set of outcomes or characteristics of the energy system, such as investment in new types of technology and resulting greenhouse gas (GHG) emissions, which in turn will affect the interactions between these actors. The ease of, and pathways to, new outcomes (more sustainable, affordable and secure energy) will depend on these interactions and will almost inevitably involve changes in them.

Energy systems are made up of multiple actors (i.e. manufacturers, technologies, energy suppliers, customers, regulators, policy makers, non-governmental organisation and so on) which have dynamic and structured inter-relationships. A theory of managed energy transition requires bringing together insights from multiple theories of transition including economic theories (such as neo-institutional), socio-technical transition theory, co-evolutionary theory; policy paradigm theory (including comparative analysis); and energy policy analysis. However, the theory also attempts to build on these theories by incorporating additional elements identified as required by previous critiques, especially in the account of politics and a more explicit recognition of actors and agency.

The rest of the paper is structured as follows. The next section provides an overview of these different theories of transition, including what seem to be important insights as well as possible gaps in the explanation of transitions. Section 2 introduces and lays out our proposed approach. Given the importance of the need to augment the account of politics in existing theories of transition, we review some central ideas in current political theory, including policy paradigms and varieties of capitalism, which play important roles in our approach. We then go on to consider the importance of specific path dependence in the energy sector, and the potential role of geographical and historical "accidents" in shaping sustainable energy transitions. We then turn to the three groups of key actors whose interactions are important to our approach, making specific hypotheses, informed by some of the economic and political literature, about their agency. We then bring these elements together to consider what conditions must be in place for a sustainable energy transition to occur, and how the framework might be used in comparative analysis. A final section concludes.

1. Theories of Transition

This section reviews a number of theories of transition: those related to socio-technical transitions (STT), historical economics and co-evolutionary theory; and it then goes on to review a number of economic theories and what they have to say (or not) about sustainable energy transitions. It is intended to lay the groundwork for our ideas of the importance of the interactions of different actors and their agency with political sets of ideas, their institutions and governance.

The STT literatures highlight the complex nature of socio-technical systems. We agree with the STT literatures that the current attempts to transition energy systems towards a sustainable future are unprecedented in a number of respects and pose particular difficulties. From this, we accept the arguments that a 'managed' transition is necessary. However, the SST literatures tend to underplay the role of agency and specific actors, as well as the interactions between political institutions, rules, norms practices and outcomes. From another perspective, the institutional and evolutionary economic literature provides useful insight into lock-in; and the varieties of capitalism literature offers an interesting framework for comparative analysis. However, the economic literatures, in general, tend to ignore political factors and have limited analysis of the role of actors' motivations and the social construction of agency.

1.1 Socio-Technical Transitions and Economic History

We turn first to STT literatures, and to economic history, partly because they offer specific conceptualisations of transition, and of energy transitions, based around the notion that such transitions are social and technical in nature. This literature tell us that a socio-technical transition represents a large-scale change from one relatively stable system-state to another. What needs to be understood first, when considering processes of transition, is how a particular socio-technical system such as energy is constituted and how it works. These systems are conceptualised, importantly, as complex structures made up of a wide range of different areas across industry, technology, politics, and society (Turnheim and Geels 2012). Each system will have its own specificities, infrastructures and institutions that inter-connect dynamically across these areas (Markand et al 2012: 956) and this point informs how we, below, construct our framework for analysis. Each socio-technical system is also likely to inter-relate with, and provide context for, other socio-technical systems. For example fossil fuel and transport systems have been intrinsically inter-linked historically and practices in each have tended to both influence and support and embed certain, carbon intensive, practices in the other. As such fossil fuels can be understood as making up one broader area in which powerful path-dependencies have arisen that have so far impaired low carbon transition – a point to which we return in section 2.2 below.

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

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

As such, socio-technical transitions infer 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 lose out (Fouquet 2010: 6591). This is partly why some incumbent groups are heavily involved in pitching their, often not inconsiderable, assets at resisting change, or at least at influencing what kind of change takes place (ibid 2010: 6592).[2]

In terms of thinking about *why* change actually takes place, niches are understood as exogenous sites of 'revolutionary change', in contrast to regimes that tend to reproduce normal innovation patterns (Smith 2010: 440). However it is only changes in the landscape level that can destabilise regimes thereby creating opportunities for niches to break through (Geels and Schot 2007: 400; Kern 2011: 301; Smith et al 2005: 1496). A specific example of this might be that scientific knowledge about climate change, considered as exogenous to the fossil fuel regime, has put pressure on current regimes of energy production and consumption to change. This has in some countries allowed for new niches to break through, for example energy produced from renewable sources, and form part of an emerging but alternative regime of energy production and usage. As such niches are understood to have historically played a vital role in energy transitions in that they offer new and alternative ways of meeting social needs (cf. Fouquet 2010; Schot and Geels 2007 and 2008). It is this vital role of new technologies, combined with the need to protect new technologies during development phases, that lead many STT scholars, and economic historians, to argue that new, sustainable energy technologies need government support.

It can be observed, however, that STT literatures are better at explaining resistance than change and, in particular, do not concentrate on explanations of why transition occurs. One recent paper has, for example, suggested that '…the destabilisation of regimes is assumed to happen' but how and why destabilisation might occur is not explored in detail (Turnheim and Geels 2012: 35). Destabilisation is seen within STT literatures as an exogenous event – whereas reasons for change, as we will see in section 2.1 below, can also be endogenous to regimes.

One further critique of sociotechnical transitions literatures is that despite claiming a central role for policy in transitions and whilst emphasising the existence of complex inter-dependencies between areas it does not analyse politics or political decision-making in any great detail (cf. Fouquet 2010: 6591; Meadowcroft 2005; Kern 2011). This is problematic in particular when considering the claim here that sustainable energy transition is, to a large extent, a *managed* transition. There has been a tendency to focus on proscribing what individual policies could or should be rather than questioning the political and institutional circumstances that make the adoption of certain policies more or less likely (Meadowcroft 2011: 73; cf. Shove and Walker 2007: 4) and which may alter the outcomes of policy decisions in practice. The politics of managed transition can, as a result, come across as being quite straightforward when the reality has been very different in many countries (cf. Kern and Howlett 2009). As such although STT 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). The below section on politics and institutions seeks to build in a greater

[2] 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) – see our discussion of actors in section 2.3

degree of understanding of how politics and political institutions interact with other areas within energy systems to inform, colour and constrain the nature of change.

What can be taken from STT literatures, and especially from historical economics,[3] is that sustainable energy transition is both highly complex and dynamic but also that it is unprecedented in contrast to previous large-scale energy transitions in a number of respects. For example, time is central to sustainable energy transition and its success in mitigating climate change. Scientific knowledge tells us that our atmosphere is limited and that carbon dioxide emissions growth should be limited both in terms of amount and time. On the other hand, however, previous large-scale energy transitions have taken between 100-150 years to complete (Fouquet 2010). Secondly, the drivers of previous transitions were strongly related to highly tangible changes in products and services, or at least in cost and profit structures to businesses. This time, for example, end users are being asked to pay more for a service that, in a tangible, individual sense, is the same as the previous service. For example a light switch flicked on will still emit light – it is just that the source of that light will be low carbon. These differences, combined with the need for new technology support, mean that sustainable energy transition need to be managed and that government support is considered a requirement to enabling transition.

1.2 Co-evolutionary Theory

Building on the STT literature, Foxon (2011) draws on work from ecological economics and MLP to put forward a co-evolutionary approach to the issues and challenges in overcoming lock-in to high carbon systems. The framework provides a tool for analysing low carbon transitions, and it pulls in a wide range of insights from a number of other disciplines reflecting the diverse areas within a socio-technical system. These include: evolutionary economics; innovation systems; industrial dynamics; as well as socio-technical transitions as ecological economics. The framework is based on five key elements or systems where change may occur:

1. Ecosystems are defined as systems of "natural flows and interactions that maintain and enhance living systems" (Foxon 2011: 2262) highlighting the relationships, influence and constraint's between natural systems within human, technical and economic systems.
2. Technologies are described in terms of systems of "methods and designs for transforming matter, energy and information from one state to another in pursuit of a goal or goals" (ibid: 2262), highlighting the application of natural processes to fulfil human purposes.
3. Institutions are described as "ways of structuring human interactions" (ibid: 2262) which can include things like regulatory frameworks, property rights and standard modes of business organisation
4. Business Strategies are defined as "the means and processes by which firms organise their activities so as to fulfil their socio-economic purposes" (ibid: 2262). This therefore includes the profit-orientated nature of firms as well as more social returns through social enterprises.
5. User Practices are defined as "routinised, culturally embedded patterns of behaviour relating to fulfilling human needs and wants" (ibid:2263) as such this picks up the relationships between users behaviour, habits, and practice, etc.

[3] Foremost works include: Fouquet 2007 and 2010; Foxon et al 2005; Geels various; Geels and Schot 2007; Kern 2011; Kern and Howlett 2009; Meadowcroft 2011; Perez 2002; Rotmans et al 1998; Shove and Walker 2010; Smith et al 2005 and 2010.

In setting out these different systems, Foxon highlights that they evolve under their own dynamics, as well as co-evolving with each other, as they can influence, and be influenced by, other areas through the causal relationships that exist between them; something that is highlighted in the wider STT above, e.g. Markand et al (2012). As an 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 particular practices. As such, it is apparent that it is not just the systems that are important for analysis, but the interactions between them and this can include the development of joint structures which can be stable over time, but can equally be disrupted from the dynamics that exist within and between different areas.

Foxon suggests that the co-evolutionary approach gives a single framework where change and influence across the micro, meso and macro levels of 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 theory also introduces the importance of actors or the role of agency in influencing change within and between the different systems. Although the outcomes of such influence can be uncertain, the process is important and links to the idea of path creation (Garud & Karnoe 2001; Geels & Schot 2008 in ibid 2263). As such, the combined analysis put forward takes account of both the dynamic interactions and mutual stability that can exist between differing systems and actors.

The framework developed by Foxon does not seek to provide all the answers; rather it provides an analytical tool for analysis of low carbon transitions. A number of examples of its application are provided, which show the benefits of taking a co-evolutionary approach. It can bring light to some of the complexity that exists within and between systems to understand what drives and hinders change, and as such gives some insight into where research attention is needed. As this paper goes on to set out, one potentially important missing element within the co-evolutionary framework is the political system – whilst this does cut across other areas identified by Foxon, politics plays a significant role within sustainable energy transitions, shaping where and how influence can happen and how this may impact the dynamics within and between systems. The framework also does not provide much detail on what is contained within each system and its sub-elements and importantly what is happening and who is involved in the interactions between them. As we go onto to explore in section 2.2, actors have a key role in enabling and constraining change and as such, they both influence and can be influenced by, the wider dynamics within other systems.

1.3 Economic theory and sustainable energy transition

Economic theories are not constructed around sustainable energy transitions as such, being rather intended to explain general economic outcomes and change. However, they do offer hypotheses about particular aspects of such transitions, including what can be expected to promote or impair innovation.

Neo-classical economics,[4] often regarded as the "mainstream" and as influential over economic policy making in many countries, sees effective *policy design* as central to the transition to a low-carbon economy and energy sector. Market failures from unpriced negative environmental externalities and positive spillovers from R&D and learning effects require both carbon pricing and support to technology development (e.g. to develop

[4] Neo-classical economics provides much of the intellectual underpinning to the dominant liberal market paradigm found especially in the UK and US. However, unlike neo-liberalism, which sees government failure as always worse than market failures, neo-classical economics has a more balanced view and can provide arguments for public policy intervention based on market failures, while being aware of policy costs.

renewable energy) (Jaffe et al 2005, Stern 2007) – in this there is agreement with STT analyses above. Papathanasiou and Anderson (2003) also argue that because of uncertainties about the costs both of climate change and of mitigation, there is an options value to learning more about the performance of low carbon technologies through their development.

Thus far, however, it has not been possible to establish stable carbon pricing. This is for both technical (for the EU emissions trading scheme see Grubb et al 2013) and political reasons. Rational choice political economy does provide an account of the political problem – governments will have difficulties in imposing carbon pricing because winners are mainly future generations while losers are all energy consumers, i.e. voters and energy-intensive industries which form a well organised lobby (e.g. Markussen and Svendsen 2005). The prescription is de-politicisation of climate policy through delegation to an independent agency (e.g. Helm et al 2003), and the UK has a weak version in the form of the Climate Change Committee. However, delegation does not always work, especially when crises occur, and it is not possible to isolate processes fully from politics (see Posen 1993, 1998 for the case of monetary policy and Lockwood 2013: 26-28 for a discussion of climate policy). Indeed, in countries which have proceeded furthest and fastest along the energy transition, progress was made not through depoliticisation but rather through building political coalitions and seeking increasing political returns (Lauber and Jacobsson 2006, Michaelowa 2005, Lipp 2007).

The failure of carbon pricing in the short term makes low carbon technology policy even more important (Kaluhl et al 2011). The neo-classical view is that cost-effective support mechanisms should be "technology neutral" and market-based because of asymmetric information problems and the risk of capture (see the discussion in Watson 2008). Such views underpin the adoption of quota-based mechanisms, such as the Renewables Obligation (RO) in the UK. However, there is clear evidence that the RO has in fact been more expensive than the technology-specific feed-in tariff approach taken in many other European countries (Ragwitz et al 2007, Lipp 2007, IEA 2008, Mulder 2008, Butler and Neuhoff 2008) and has excluded smaller actors through high levels of risk (Mitchell et al 2006) and incentivised the geographical clustering of windfarms, both of which have produced planning opposition (Szarka 2006).

Beyond technology support policies, innovation within energy transitions may also depend on market structures. There is disagreement amongst economists about whether competition is good or bad for innovation (see Cohen and Levin 1989 and Gilbert 2006 for reviews). The recent literature focuses on specific factors of competition (Boone 2008, Gilbert 2006, Vives 2008), and suggests that the characteristics found in energy markets (low product differentiation, difficulty of providing effective intellectual property rights protection, and high barriers to and costs of market entry) tend to militate against innovation (Defeuilley 2009). Of these, the last is the only one amenable to policy, so one implication is that transition will be faster where governments actively make it easier for new entrants to enter energy markets.

Beyond the mainstream various schools of new institutional economics5 do provide accounts of change but these are, as with STT theories, generally weaker than their explanations of why institutions persist (Kingston and Caballero 2008). Some approaches explain institutions as arrangements that minimise transactions costs (Coase 1937, Williamson 1985, North 1990) and solve collective action problems (Ostrom 1990), and emphasise their stability, in the absence of exogenous shifts in relative prices or technologies.

5 For recent overviews see Chavance 2009, Ménard and Shirley 2008, Alston 2008 and Brousseau and Glachant 2008

However, since managed transitions are precisely about trying to bring about such shifts, these accounts are not particularly useful in explaining how such transitions might happen.

Evolutionary economics, based on adaptive expectations and increasing returns, provides an account of how initial competition between technologies can move swiftly to lock in one while excluding others (e.g. Arthur 1989). Such transition processes display path-dependence, in the sense that small initial advantages can lead one technology to dominate over others (e.g. David 1985). However, once locked-in, a dominant technology can be difficult to dislodge (Farrell and Klemperer 2007). Unruh (2000) has applied these ideas to high-carbon energy systems, producing the problem of "carbon lock-in" through increasing returns to technologies and institutions within firms, in industries, in government and in the wider society. Again, while this account provides useful account of how institutional systems persist, the issue of how to escape carbon lock-in is not so clear. Ultimately, the main conclusion is that escape is a coordination problem, which in the case of managed transitions also means that there is a central role for public policy.

Overall, while economics has no explicit theory of sustainable transitions, it can offer some useful insights. One is the focus on actors, agency and the emergence of institutions such as markets as the outcome of interactions between actors, whether strategic or unintended. Institutional and evolutionary economics provide a number of ways of understanding lock-in. The "varieties of capitalism" variant of institutional economics offers a clear and interesting framework for comparative analysis. However, economic theories also have some serious limitations. The treatment of technology is too narrow and abstract, making assumptions not borne out by evidence. The same applies to the assumptions about actors' motivations, which ignore the role of ideas in the social construction of agency. At the same time, much economics also trends to ignore political factors.

2. Developing a New Framework: Towards a Theory of Managed Energy Transition (TMET)

An analytical framework capable of explaining differences in transition speeds and pathways between countries must have certain characteristics. It must have clearly identified *actors* and a *theory of action*. As in Foxon's approach, it must explain current practices and outcomes (including investment in and the development of technologies) as well as transitions as *emerging from the dynamic interaction* between those actors and the systems that they both create and are part of, intentionally or unintentionally. It must have an account of *politics*, as well as economics and technology. It must also make *specific hypotheses* as to why countries differ.

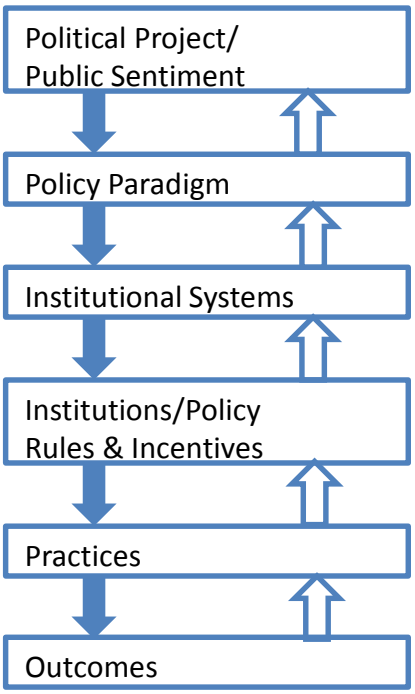
In developing this framework, our focus is mainly on the politics and economics of transition, and how this interacts with users. This is because user practices and routines are often susceptible to change where there are sufficient economic incentives or political will to transform the nature of energy demand (e.g. Unruh 2002: 319), although this is not always straightforward. 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-dependencies which colour transition in certain ways, and so these do play a more significant role in our approach.

In the case of climate change, which requires *urgent induced* technological change, coordination through public policy must play a central role (Fouquet 2010; Kuzemko 2013, Unruh 2002). This focus means that the *political, social and economic dynamics* of induced

energy transition come to the fore. For initially niche low carbon technologies and activities to become sustainable and dislodge existing high carbon technologies and activities, they have to realise increasing returns economically (i.e. economies of scale, learning and use, network externalities), create political buy-in (i.e. they have to create new institutions, framings and above all interests), and have to have user acceptance and involvement.

Figure 1, below, is a work in progress and shows a TMET conceptual overview of the way innovation occurs in a rather linear way, indicating a sense of hierarchy in terms of impacts, but as also interactive between different dimensions. This figure shows, as is explained in more detail in section 2.1 below, that policy paradigms interact with public sentiment. This is clearly linked in the sense that public sentiment votes in governments, via electoral politics, but political 'projects' or visions of governments can stimulate resonance with the public, as the Thatcher Government did at the time of state privatisations, and this can feed into a policy paradigm. A policy paradigm is broadly understood here as a set of ideas within which the Government operates, with a greater or lesser degree of tolerance and input from the public. As is also seen in more detail in section 2.1 below, the policy paradigm establishes institutions which reflect that policy paradigm, and this can create inertia and/or momentum in the system because of the tendency for institutions to persist. The rules and incentives are created by institutions, but it is the policy paradigm's ideas which shape the 'rules of the game'. These rules and incentives in turn drive the practices of actors involved in the system and together these lead to outcomes, which in turn inputs into public sentiment.

Figure 1
Conceptual overview



Ultimately none of these interactions are linear or uni-directional; nor are the framework dimensions homogenous. For example, institutions of a policy paradigm can have noteworthy differences between them. Figure 1 shows the links between the dimensions as only with their immediate neighbour, whereas we would argue, for example, that practices can impact on public sentiment. We have tried to show this interaction between dimensions in Figure 2

below which serves as an alternative articulation of these interactions. However, conceptually, we argue that some interactions are more important than others, in particular that the policy paradigm holds together the institutions and their rules and incentives. While there may be changes, fundamental change will not happen without a change to the policy paradigm. In this sense therefore, the equality of interactions as shown in Figure 2 is inappropriate. We hope to develop a figure that can encapsulate the interaction as dynamic and as between each dimension as well as inferring that some interactions carry more weight.

As was explained in the opening lines of this paper, we seek to understand 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. The rest of the section look in further detail at what we argue are the three building blocks for innovation and transition in the energy system, and how they interact: the policy paradigm, the politics and institutions; the historical and geographical factors of a country; and actors and their interactions.

2.1 Politics, Institutions and Varieties of Capitalism

This section speaks in more detail to Figure 1 above, and Figure 2 below, and attempts to inform a better explanation of the politics of transition – and specific ways in which energy transition is coloured and constrained. Recent analyses have suggested that one way of formulating a more in depth understanding of the politics of sustainable energy transition, or in other words what shapes the rules, is through analysing the institutions and ideas that inform specific governance choices (cf. Kern 2011a; Meadowcroft 2011). Just as STT analyses emphasise the ability of rules to constrain technological choices so too are political institutions, and policy choices, understood here as being influenced by sets of ideas and interests that encourage certain choices over others (Hall 1993; Mitchell 2008; Kuzemko 2013). This kind of thinking is typified in the claim that a 'band of iron', defined largely by the wider regulatory state paradigm, has constrained and coloured sustainable energy policy in the UK (Mitchell 2008; cf. Kern 2009). These analyses tells us a great deal about specific constraints on sustainable policy choices as well as helping to understand sustainable energy policy in relation to wider political institutions – underpinning arguments in STT and co-evolutionary literatures about the inter-connected nature of socio-technical systems.

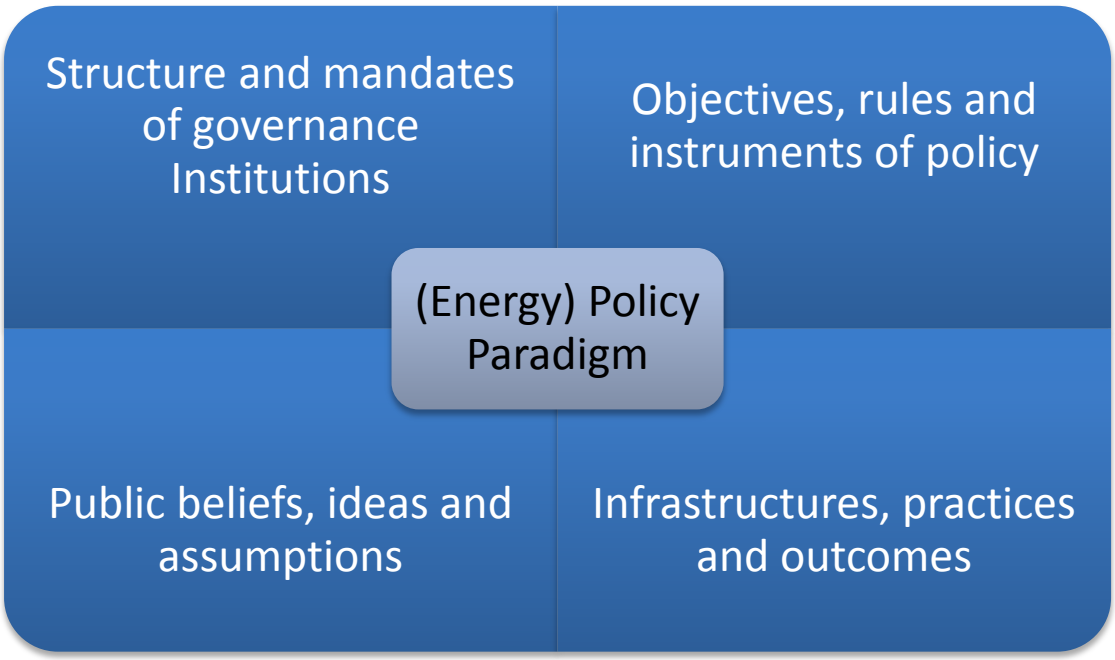
An emphasis on rules and regulations, however, leaves little room for explanations of change, or of the processes that are somewhat hidden behind these more visible, structured outputs of the political system. To understand a bit more about how rules and regulations are constituted we turn here to historical and sociological institutionalism and associated theories of policy paradigm change (Hall 1993; Blyth 2002; Campbell 1998; Hay 2001; Oliver and Pemberton 2004; Schmidt 2008). 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.

Within new institutionalism, as in many other approaches to explaining the political economy, it is understood that that policy decision-making and choices are influenced not only by interests and material factors but also by ideas, institutions and belief systems (Hall 1986: 19; cf. Campbell 1998; Berman 1998; Blyth 2002). In this way material factors, such as fossil fuels, are assigned certain socio-economic functions that relate to the interpretation of these factors and their utility in meeting societal needs – a claim that we expand on in section 2.2 below. Politics can be understood as a struggle for power played out in significant part through arguments about the 'best story'' (Fischer 2003: x) – the audience is made up of elites and stakeholders but also, importantly, the voting public. The '*best* story',

which then shapes how a issue area is addressed in policy terms, is underpinned by sets of ideas often referred to as an interpretive framework or a policy paradigm (cf. Hall 1993; Schmidt 2008). These policy paradigms influence decision-making on a number of different levels - including how policy areas, such as energy, are perceived as well as what the *objectives* of policy should be and which *instruments* can be used to attain these objectives (Hall 1993: 279). Policy choices are also influenced by a need to speak to and address public sentiments, assumptions and beliefs (cf. Campbell 1998), particularly during periods of change to policies and during general elections.

Policy paradigms once they are accepted as the 'best story' become embedded institutionally thereby influencing not only what policy objectives, instruments and rules are put in place, but also the design of those 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 but not enough is made of these interconnections in theories of policy paradigm change which is why we seek to include practices and outcomes in our framework of managed transition. These observations are encapsulated in Figure 2. This diagram is designed to reflect the notion that there are interactions between different dimensions of the energy governance system, the policy paradigm, the objectives, instruments and rules, the structure of energy institutions and public sentiments. It is also designed to suggest that these flow both ways - if not always to the same extent at certain points in time – but come together to infer certain outcomes and practices coloured by the policy paradigm and its institutionalised structures. These interactions include successful attempts to structure as well as attempts to change policy paradigms, institutions, rules, incentives and practices.

Figure 2
Articulation of a Policy Paradigm and Related Structures



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', or narrative, to fit the socio-political context. The climate change narrative, based upon new scientific knowledge and the need for mitigation, can be understood for the purposes of managed energy transitions as the framing that best fits current social needs and the environmental context. Current framings of energy as a policy area are, however, also related to security, poverty and economic arguments (Kuzemko 2013) – and each will find a different degree of support from different groups including publics. The 'best story' ultimately is understood, theoretically, as the one that finds sufficient political, commercial and public purchase such that political changes can be enabled – often in times of crisis (cf. Hay 1996).

The political context will, therefore, be made up in part of those narratives that frame the need for profound change, such as transition, differently and offer different sets of solutions to how it might be achieved. *This is important in that the 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 (Scrase and Ockwell 2009; Kuzemko 2013). The political context is also, however, existing political and corporate institutions that may interpret and explain energy problems differently, and thereby also influence how change takes place (cf. Hall 1993; Blyth 2002). Recent literatures on UK energy policy, as well as work on global climate governance, have claimed that one interpretive framework, neoliberal economics, has heavily influenced decisions in relation to energy transition. In particular, the degree to which the idea that the role of government should be limited has become institutionalised in energy governance institutions over time has severely limited policy choices and outcomes in the UK (cf. Jacobs 1991; Bernstein 2002; Meadowcroft 2005; Carter 2007).

As a specific example of the impact of the neoliberal economic paradigm on energy transition we can look at the role of the private sector in providing vital energy functions society and how it colours transition in the UK. Large energy corporations have not only become central to the delivery of energy goods and services but they have also become the *main conduit through which energy policy can be enacted*. This has inferred important and particular power relations between policymakers and private energy industries and financiers. As a result of these power relations the private sector, particularly large energy and finance companies, have enjoyed a higher degree of influence in that "… maintaining business confidence and conditions become key state concerns" (Meadowcroft 2005: 492). The addition of climate objectives has arguably changed the function, or objective, of energy policy, but climate change mitigation has been framed in such a way that targets could be adopted without undermining the basic structures of the neoliberal economic policy paradigm (Bernstein 2002). Power had become a question of successfully framing and representing problems in order to downplay other, potentially viable, alternative interpretive frameworks and solutions (Smith et al 2005).[6] In practice, therefore, 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 sustainable energy has not been seriously challenged by public opinion in the UK in that support for climate change mitigation as not been a significant part of the political landscape.

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

These path dependencies are to some extent specific to the UK. But these are clearly not the only policy paradigms that currently influence energy and climate policy choices – capitalism is not monolithic (Hall and Soskice 2001; Schmidt 2002; Crouch 2005). The "varieties of capitalism" (VoC) framework (Hall and Soskice 2001) recognises and explains such diversity. It observes that firms face transactions costs and coordination problems in a range of areas from bargaining over wages, training, acquiring finance, managing supply chains and incentivising employees. Hall and Soskice (2001) posit that different countries have evolved distinctive national institutional systems that solve these problems in different ways. Liberal market economies (LMEs) like the US and UK, where firms coordinate activities primarily through arms-length exchange through contracting in competitive markets, and coordinated market economies (CMEs), where firms rely more heavily on non-market deliberation processes. Although widely criticised, the VoC approach may be useful for understanding comparative differences in the speed and nature of change. Including a variety of capitalisms approach emphasises further the notion that certain policy choices and institutional structures might not necessarily be 'right' or 'wrong' but related to specific, domestic political and institutional contexts as well as interests, material factors and power relations. As assessment of how successful certain choices have been in relation to encouraging niche innovations can still be conducted but understood and explained in relation to specific contexts.

For example it has been argued that CMEs are institutionally more suited to governing for sustainable energy transition than market economies, like the UK (Mikler and Harrison 2011). This is especially given claims within STT about the need for a *managed* transition and is partly because of tendencies for managed economies to prioritise collective over individual action. By contrast it is claimed that:

> "(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)

CMEs 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 2005: 441). Germany, the archetypal CME, does indeed have a superior track record in supporting new energy technologies and in showing leadership - not least in that they have consciously designed and co-ordinated long-term plans for energy system transition. 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).7

The models of capitalism approach in application here therefore assists in explaining *why* it has been easier for Germany, as a coordinated economy, to take this transition route as opposed to LMEs, such as the US or UK. This is partly because the relevant ideas and institutions were already in place: managing, long-term planning and coalition building represents a greater part of its institutional make-up. Moreover, public sentiment is also more supportive of sustainable energy transition. There is 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.

7 These observations 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).

These observations suggest the ways in which energy policy is related to broader sets of ideas about politics, for example about individualism and collectives, about the role of public beliefs and about the forms that inter-relationships can take between actor groups within an energy system. But 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, and this point is related, much about the actions and motivations of other stakeholders within energy systems – such as end users or incumbent and emerging energy companies.

2.2. Historic and Geographic Factors

Political constraints, policy paradigms and economic institutions affect policy objectives and instruments and in turn practices and outcomes in all areas of policy, from health to education to the economy. However, there are certain respects in which energy is different from other areas of policy, which makes energy specific knowledge important to energy policymaking. One of these, as noted above, is that energy is seen as having aspects of a public good and as being of importance for national security. Another is that (like transport and the built environment) energy infrastructures can be expensive and very long-lived. Once actors, like private or national energy firms, make investment decisions about infrastructures they have a major effect on subsequent decisions by actors in the energy system, and will exert different influences on the shape of energy transitions in different countries. As such different national energy systems will have infrastructures in place that relate in different ways to low carbon transition. For example, the Danish government responded to the energy crises of the 1970s and 1980s by adopting district heating and CHP and developing a heat infrastructure on a large scale, as well as pursing wind power. This now puts Denmark in a different starting point for the transition to a low carbon energy system, as compared with, say, the UK with its combination of centralised electricity generation and a gas network and individual boilers.

This endogenous aspect of path-dependence in energy is well-known and covered well within both economics and STT literatures. However, in our approach, we also recognise important historical and geographical factors that also tend to have lasting effects. Consistent with our emphasis on the importance of politics in energy policy and transitions, we argue that the transmission mechanism by which material factors affect energy outcomes are primarily political. Two types of factors are particularly important.

The first are the patterns of geology and geography by which fossil fuel energy resources have been distributed, and the temporal factors by which they have been discovered in particular countries. Most current sources of energy are fixed in terms of geographic location and finite in terms of their geology (Hadfield 2008). This aspect, within a world still divided into sovereign nation states that value access to sources of energy highly, has historically made energy subject to much political interest, strategy and sometimes conflict internationally (cf. Venn 1986). Furthermore, 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. The obvious example of this is the level of oil usage in countries like the United States and Saudi Arabia that have had long, easy access to plentiful supplies, and the implications that this has for public sentiments about energy.

A further example of the relationship between indigenous resources and politics is that the UK's response to the energy crisis in the 1970s and 1980s was, because of the discovery and exploitation of North Sea oil and gas, to worry far less about efficiency policy. As noted, the importance for energy policy lies not so much in the existence of the resource *per se*, but in the political significance of the lobby that arises from it. The exploitation of

oil, gas and coal in a country produces employment, tax revenues and at least the perception of greater energy supply security, as well as lobbies with political power in proportion to those effects. However, such exploitation is further dependent on other political factors; although the UK has plenty of coal, its coal industry and lobby were effectively destroyed in the aftermath of the 1984-85 miners' strike. By contrast the coal lobby in Germany remains strong.

A second material and political factor of an energy system that can constrain and colour change is the historical role and status of civil nuclear power. Those countries which have had a geo-political interest in the military use of nuclear power after WWII tended to develop a civil nuclear resource. This dual function of nuclear power arguably considerable political power to the nuclear lobby – something that is now being augmented for some by its low carbon credentials. Such countries include the UK and of course France where nuclear energy is also often understood to have positive energy supply security aspects given that it is indigenously produced and therefore less subject to external geopolitical shocks (this works when notions of energy security are geopolitically informed – as during the recent Russia-Ukraine gas transit disputes). Other countries, especially in continental Europe, did not become nuclear powers (or in the case of Germany were not allowed to) and indeed felt exposed by the threat of nuclear war, consequently becoming more prone to powerful anti-nuclear movements.

These legacies of history and geography not only shape attitudes towards transition now but have historically shaped the responses of different countries to energy shocks or crises, 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 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.

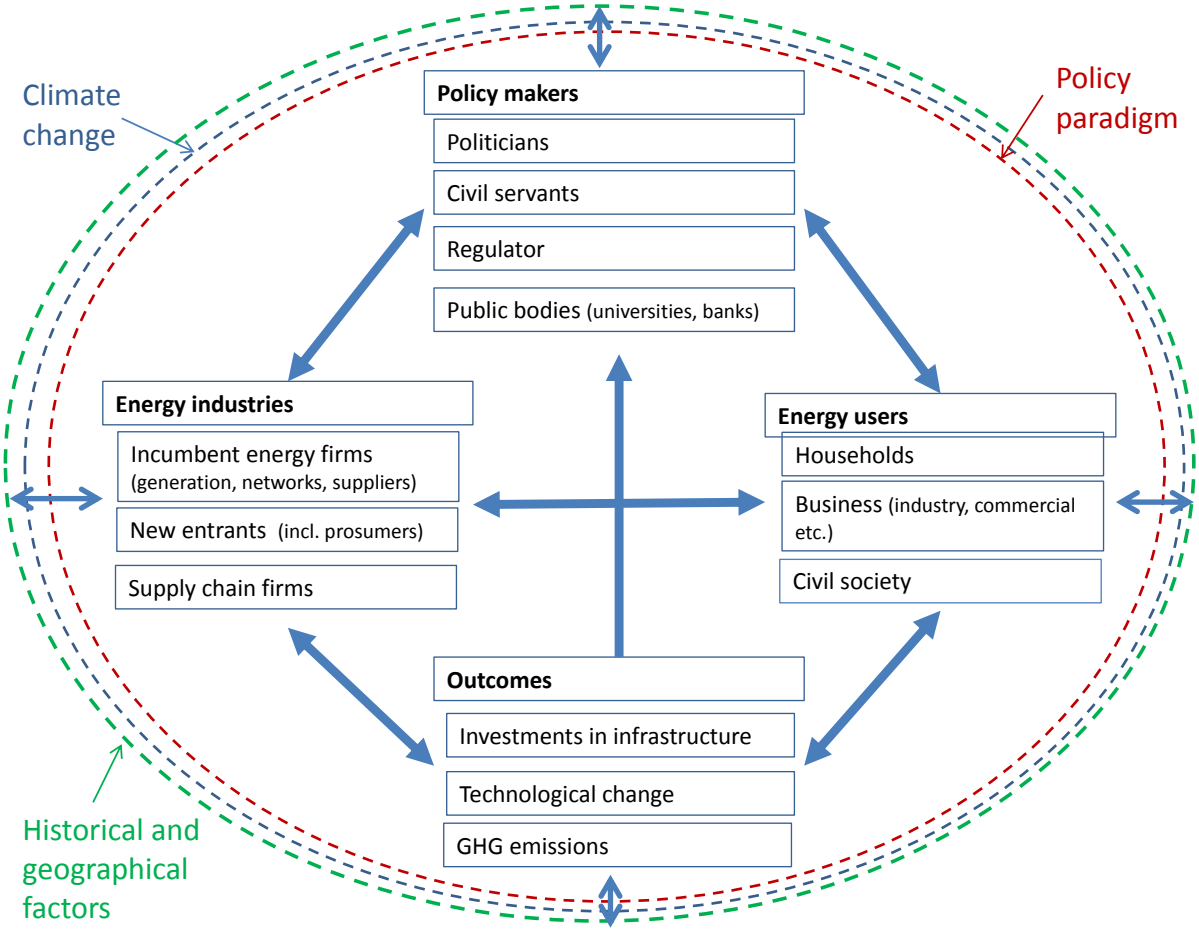
2.3 Actors and Interactions

As discussed above, our approach lays an emphasis on understanding emergent regimes and transitions in the energy system as arising from the dynamic interactions between actors. Actors thus have a critical role in our account. Drawing on the social conflict variant of new institutional economics (e.g. Acemoglu et al 2004), we focus particularly on actors who have political power, whether this is formal or informal in nature. We argue that three groups of actors could be argued to matter for explaining an induced energy transition; *energy providers*, *policy makers* and *users of energy* (e.g. Scrase and Smith 2009: 710). For an approach that is to be useful for comparative analysis, it also necessary to make some statements or *assumptions about what drives actors*, and consequently what kind of emergent institutions and outcomes we would expect to see in different configurations. At the same time, these assumptions must be sufficiently general so as to be applicable across many settings.

Interactions between these actors lead to the development of institutions, including energy markets, which ultimately determine investments in particular technologies and

activities, 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).

Figure 3
Actors and agency in the energy system – a Theory of Managed Energy Transition



In most countries, energy investments pre-transition will be dominated by *incumbent energy firms*. It is reasonable to think of incumbents as primarily motivated by the anticipation of profit, adjusted for risk. How long- or short-term a view such companies take depends on corporate governance and finance, i.e. the attitude of shareholders. Once investments in particular technologies have been made, these investments shape both the 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 (see also above section 2.2).

The investment decisions of incumbents will be shaped heavily by institutions (rules and incentives) set by policy-makers. However, incumbents also seek to shape policy, through lobbying, secondments to government, and sitting on technical committees that shape markets. As discussed in section 2.1 above, the political power of large energy incumbents arises indirectly from the fact that they control energy production and supply, and politicians fear the response of voters to the possibility of the lights going out. The fall-back position of large incumbents is to threaten such a possibility through investment strikes (Jessop 1990) or exit (i.e. divestment). A key objective for incumbents in influencing regulation and policy

will be to maintain high costs of and barriers to entry (e.g. Stigler 1971). How successful they are in this will determine how far *new entrants* can gain access to energy markets. New entrants are often 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). Analyses such as Stenzel and Frenzel (2008) also 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. If not, incumbents will tend to lobby against policies and regulations. 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.

In setting policy *politicians* will, in addition to policy paradigms, be partly structured by what voters think and want and *regulators* typically have consumer interests (in particular promoting competition and minimising costs) written into the core of their remit.8 Policy since the 1980s has sought to depoliticise the energy system, so that at the beginning of the transition there are typically low levels of interest in energy (Devine-Wright 2006, Kuzemko 2011: 64-65). In most countries, most *households* are generally concerned about climate change (to varying degrees) and want to see change towards low-carbon energy (preferably renewables). Because the political power of households is so dispersed, civil society organisations play a key role in lobbying policy makers for these goals. Thus policy makers will care about system outcomes such as changes in GHG emissions. However, the salience of these issues for households is often low relative to the perceived cost of energy services, and there is limited willingness to pay for low-carbon energy (Harrison and Sundstrom 2010, Lockwood 2013, Carter 2008), and as a result policy makers will also be concerned about the costs of policy. *Business* outside of the energy sector is also both politically important, 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". For policy makers, the interests of these energy consumers and wider society have to be weighed against those of energy provider incumbents (e.g. Peltzman 1976), including the fact that consumer costs are industry revenues. Much policy making in the energy regime is dominated by the balance between these two forces.

However, in addition to interests, all actors in government are also driven by ideas. Narratives about climate change driving a need to reform the energy sector are important for politicians, although the degree to which there is elite political consensus on climate change varies across countries (Harrison and Sundstrom 2010). But perhaps most importantly, policy makers work within *policy paradigms*, which are discussed in detail in section 2.1 above. Such sets of ideas shape and constrain thinking about policy, setting limits on what is and is not considered possible. They influence all actors, but policy makers most profoundly. The main shift in paradigms since the 1980s has been towards neo-liberal economic principles,

8 *Civil servants* can also have an influence on energy policy making, because siloing in government often prevents effective coordination of policy across departments. However, this problem is of a lesser order than the interactions discussed in the text.

although the degree to which this has happened has varied between countries (Hay 2007, Blyth 2002, Schmidt and Radaelli 2004).

In this approach, institutions governing energy markets, energy networks and the development of energy technologies are results that emerge from the interaction between the actors outlined above. These also interact with each other. The institutions that govern energy markets, networks and technology development are all shaped by regulators and officials instructed by politicians. Politicians are guided by ideas, both climate change science and the dominant policy paradigm. However, they are also influenced by the interests and views of energy users (households and businesses) and those of the energy incumbents and energy resource lobbies. The patterns of investment in the production of energy (and in energy service demand) in turn affect the interests and views of the different actors, especially in relation to changing costs and asset ownership.

3. Transitions and comparative analysis

This section builds on sections above that work insights from various literatures into our framework, but also emphasises the importance of practices and outcomes to a framework of managed transitions.

3.1 Sustainable energy transitions

We identify here certain conditions that make a sustainable energy transition more or less likely within this framework, associated with the key interactions. A first, basic condition is to do with the basic nature of energy investments. For new practices and outcomes of actors in the energy system (especially commercial actors) to change in the direction of sustainable energy, there will need to be opportunities to capture flows of revenue (including from support mechanisms) from these new practices and outcomes, greater than the costs which arise. 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*.

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*. The inclusivity or exclusivity of markets will relate partly to the power of incumbents, as discussed in section 2.3 above.

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 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*. 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 other background factor, 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*. This critical issue is discussed in greater detail below.

Consider how such conditions might lead to the emergence of a successful sustainable energy transition through the interactions we outline above. At the start, 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. Answers to these questions are needed to be able to apply this general framework to specific settings, for comparative analysis.

3.2 Comparative analysis

Industrialised democracies share many features of this approach that are common. All have an energy market with at least some incumbent companies and a regulator. All have publics

who are concerned about energy costs, and to a varying extent, climate change and other environmental issues. All have political leaders who face regular elections. However, there are also some key differences that our approach implies will explain much of variation in outcomes. In particular, based on the nature of the analysis of actors, interactions and conditions for sustainable energy transition above, we argue that the speed and pathway of energy transition in any *specific setting* will depend mainly on two factors:

i) the nature of the *dominant policy paradigm and related economic institutions*
ii) factors (such as historic or geographical) creating path-dependence in energy systems

i) Role of policy paradigms and institutions
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. There are multiple implications of the strength of neo-liberalism for the energy transition, some of which are less obvious and direct than others:

- policy makers in a neo-liberal paradigm have an ideological commitment to particular policies over a more pragmatic approach (Kuzemko 2011, Kern and Mitchell 2010), which can increase policy costs
- 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
- more generally, the stronger the neo-liberal paradigm the more short-term financial costs dominate decision making; and the more difficult it is for climate change and other environmental ideas to influence policy. At the same time, 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 pathways involve making choices. Regulatory institutions and rules designed for minimising costs will not be fit for the purpose of managing energy transition.
- sunk costs and economies of scale mean that there are significant barriers to entry, so that privatisation and liberalisation of the energy sector has paradoxically led to high levels of market concentration. 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.9 Where divestment has been less thorough, energy producers and suppliers owned by the central state or municipalities 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.10
- 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

9 Technical codes such as CUSC and BSC effectively impose large costs of participation in electricity wholesale markets, for example.
10 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).

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.11

- where electricity networks and the system operator function are owned by private firms that have to bear the uncertainty or costs of adapting network operation this creates an incentive that works against investment in low carbon technologies that are disruptive for current network operation (Stenzel and Frenzel 2008).
- Clearly 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; 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).
- The neo-liberal paradigm addresses problems that difficult to deal with within short-term political cycles by depoliticising them through delegation (Kuzemko 2011: 61, Hay 2007). However, depoliticisation is not effective in crises or transitions (Lockwood 2103, Posen 1993). In countries where the neo-liberal policy paradigm has not been embraced so strongly, policy makers are more likely to seek durability through policy design that explicitly seeks increasing political returns.
- As noted in section 2.1 above, the more thorough adoption of a neoliberal policy paradigm is more likely in countries with more market-based economic institutions (Schmidt 2002, Hall and Soskice 2001). Finance in liberal market economies (LMEs) is dominated by share ownership and pressure for short-term returns. This arrangement militates against energy firms from taking longer-term views on profits and on low carbon transition. By contrast, in coordinated market economies (CMEs), firms have greater access to more patient finance.
- CMEs have tended to adopt PR electoral systems wholesale in the early 20th century, whereas LMEs retained majoritarian systems (Cusack et al 2007). Majoritarian electoral systems work against smaller parties, including the Green parties, by comparison with proportional representation (PR) systems. Publics in North-West continental Europe may be more environmentalist, in the sense that there is a larger proportion of people for whom environmental issues have higher salience than in the UK or the US, but it is electoral systems that largely explain the difference in political representation of that view (Scruggs 1999).
- At the same time, countries with PR systems (i.e. CMEs) also have less inequality (Crepaz 1998) and higher levels of welfare provision (Iversen and Soskice 2006, Austen-Smith 2000). In LMEs, real wages have grown less, with a greater share of national income going to capital, and welfare settlements have been less generous. As a consequence 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 energy transition policy costs on energy bills. In the UK the debate on fuel poverty is more prominent than in countries like Germany or Denmark.

11 The UK industry has a high share of foreign ownership, which increases the credibility of threats of exit. Paul Golby, CEO of German owned E.On, would frequently make arguments about pulling out of the UK if certain policy conditions were not forthcoming.

ii) The role of historical and geographical factors

As outlined in section 2.2. above, energy systems are path dependent, and are affected by exogenous factors in the form of accidents of 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). We argue that these factors 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, we argue that such factors are significant, both in the speed of a sustainable energy transition, and in the shape of the pathway it takes. 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.

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, potentially crowding out the realisation of learning economies for renewables (e.g. Kalkuhl et al 2012). At the same time, 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). 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 under the guise of different arguments, 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.

4. Conclusions

Our (very provisional) analytical framework (Figure 3) is trying to explain how and why the interactions between policy makers, energy providers, energy users lead to certain outcomes. We need to move further in our understanding of what sets of ideas are more conducive to a sustainable transition within certain contexts and how interactions between the different groups can become more directed towards certain outcomes. All of these understandings must be developed with a sensitivity to the political contexts within which policymaking takes place.

Our framework enables us to do this by linking actors and agency (Figure 3) with our provisional conceptual overview of why innovation occurs in certain ways is set out in Figures 1 and 2. We see the energy system as constructed by interactions between the three groups of actors Figure 3: policy makers (politicians, civil servants, regulators etc); energy providers (energy resource firms, such as oil and gas companies, incumbent energy firms,

such as generators, suppliers, etc; new entrants); and energy users (such as households and businesses).

We should also be able to characterise the current practices within these three areas as well as to characterise what sort of practices we would expect a sustainable energy system to exhibit. In theory therefore, we can learn about the *nature* of sustainable energy transitions by looking at what is actually happening on the ground in terms of practice change and relating the nature of that practice change to the interactions between policy makers, energy providers and energy users, in turn linking that to the policy paradigm and geographical and historical resources which binds all together.

From this, we hope to identify how innovation and governance of these three areas influence the outcomes such as: reducing carbon; deploying innovative technologies; enabling investment; supporting new business models and new entrants; involving customers; reducing demand; and increase affordability.

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