Negotiating the energy policy 'trilemma' – an analysis of UK energy governance from a socio-technical systems perspective

Dr. Ronan Bolton*[1] and Dr. Tim Foxon*

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

****Draft version – please do not cite****

Abstract

This paper analyses contemporary energy governance dynamics in the UK, focusing on recent policy changes designed to promote electricity sector investment and enable the transition towards a low carbon energy system. The purpose of the paper is to analyse how UK energy governance is evolving to address the energy policy 'trilemma' of affordability, decarbonisation and energy security, and to explore potential implications for long term transition pathways to a low carbon energy system. We draw from the socio-technical systems and transitions literature to analyse new coevolutionary interactions between actors, institutions and technologies which are shaping energy governance in a period of uncertainty over the drivers for policy change and likely outcomes.

1 Introduction

The UK provides an interesting case study of energy governance as it has been a front runner in terms of privatising and liberalising its energy and other utility sectors to achieve cost reductions and efficiencies, but also in instituting a greenhouse emissions reduction target which places a legal obligation on the UK government to meet a target of an 80% emissions reductions by 2050 from 1990 levels. Meanwhile, since the early 2000s energy

[1] Corresponding author: Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds LS2 9JT, UK. E-mail addresses: eerpgb@leeds.ac.uk. Ph +44 113 343 5572, Fax: 0113 343 5259

security has begun to rise up the political agenda, in part due to the fact that the UK has become increasingly exposed to volatility and uncertainty in the international gas market as demand for natural gas has begun to outstrip domestic reserves. The policy challenges associated with meeting decarbonisation targets, improving energy security and affordability is commonly referred to the energy policy '*trilemma*', and the interaction and tradeoffs between these multiple policy priorities have been increasingly debated in the energy policy literature (Scrase and MacKerron, 2009, Helm, 2012, Foxon, 2013, Boston, 2013).

Prior to the advent of the 'trilemma', during the 1980s and 1990s the UK pioneered the development of a market based approach to energy governance. A number of authors have characterised this as in terms of a new policy paradigm, distinct from the state controlled model which had prevailed since the second world war (Helm, 2003, Kuzemko, 2013). The economic rationale behind privatisation and liberalisation was that in order to protect customers from inefficiencies and monopoly pricing, investment and operational decisions should be made in response to market signals and incentives.

Today these issues – liberalisation and efficiency, energy security and decarbonisation – sit alongside each other and there is a great deal of uncertainty as to the central policy objectives and agendas which are driving change in UK energy governance. A number of recent contributions have argued that, rather than undergoing a shift in energy policy paradigm, similar to post war nationalisation or the privatisation of the 1980s, energy governance in the UK is characterised by multiple and competing policy objectives (Kuzemko, 2011, Fudge et al., 2011), making it difficult to discern the interests and ideologies which are influencing policy change.

In the next section we propose that socio-technical systems theory can provide a useful framework to analyse the complexity and ambiguity which characterises contemporary energy governance in the UK. Following this, in section three, we chart a number of recent developments in UK energy policy, namely a decision by government to mandate a coordinated roll-out of smart metering technology, and efforts to stimulate investment in 'low carbon' forms of generation as part of the UK government's Electricity Market Reform

(EMR) proposals. In section four and five we draw from the socio-technical systems literature to analyse these developments and to inform a discussion of potential implications and insights for energy policy making in the future. In the final section we conclude.

2 Energy governance and socio-technical change

In this section we discuss how insights from the socio-technical systems literature can help us to understand the UK response to the energy policy ‘trilemma’ and contemporary energy governance dynamics.

The socio-technical systems approach is a branch of innovation theory and science and technologies studies (STS) which focuses on the interrelationships and interactions between the material and non-material components of large scale technical systems. A system such as electricity supply is seen as ‘seamless web’ (Hughes, 1983) or a ‘heterogeneous web of relations’ (Law, 2009), composed of technologies, actors, rules, texts, policies, fuels etc. In common with other STS approaches, specific aspects of a system such as technology or policy are not studied in isolation, rather the analytical lens is on how relations between the material and non-material take place and unfold over time. In recent years the sustainability transitions literature has focused on how we can operationalise this approach to understand socio-technical transitions, or radically new ways of organising and delivering essential societal services such as energy, water, transport etc. (Verbong and Loorbach, 2012, Markard et al., 2012, Smith et al., 2010)

During the current phase of uncertainty in UK energy it is likely that new institutional responses, actor strategies and technological innovations, will emerge and interact with one another. We argue that a socio-technical analysis and systems framing is well placed to account for this and can provide useful insights to interrogate how multiple policy challenges are being addressed, how different actors in the system are shaping change, and the influence of technologies and innovation in this. Applying insights from socio-technical studies can in turn contribute to a better understanding how policy change takes place in these complex socio-technical systems. Lovell (2007) for example argues that ‘[t]hinking holistically about the combined influence of material infrastructure and human actors yields a more satisfactory account of how new policy ideas and innovations diffuse and become popular' (p. 2500. See also: Teschner et al., 2013). However, in a recent contribution Kern (2012) notes that although a growing number of studies have drawn on this literature to develop policy prescriptions for sustainable transitions, there has been little analysis of ongoing policy initiatives and processes. It may be because of its roots in STS and innovation studies that there has been a lack of engagement with the political and institutional contexts which influence processes in socio-technical change - a number of authors have identified this issue as a significant gap in the extant literature on sustainability transitions (Kuzemko, 2013, Meadowcroft, 2009, Kern and Howlett, 2009).

In section four we draw from two specific contributions to the transitions literature to analyse contemporary UK energy governance: Firstly we draw upon the concept of socio-technical regimes (Rip and Kemp, 1998) to explore how the established market based model of centralised electricity provision in the UK is adapting to cope with new policy challenges. We propose that regime actors are seeking to frame the low carbon transition as a challenge of facilitating large scale investment programmes, a strategy which is in alignment with their existing resources and capacities. Secondly we draw from a recent analysis of UK low carbon pathways (Foxon, 2013) to explore in more depth how different actor framings of the energy transition are beginning to overlap and align, and we identify the early stage formation of a potential low carbon pathway based on a hybrid government/market logic.

3 Case studies of recent policy developments

Drawing on two case studies of recent policy developments in the UK, in the sections below we examine how energy governance has begun to evolve in response to the 'trilemma'. We focus on two of the key policy initiatives which are likely to influence interactions between actors, institutions and technologies in the energy, both in terms of energy use and the demand side (smart meter roll out), and at the supply side (electricity market reform). However we recognise that this does not provide the full picture and we cannot claim to provide an extensive overview of UK energy policy in its entirety. The cases draw from key policy and regulatory documents published during the period leading up to and following the 2008 Climate Change Act and Energy Act, and ongoing debates surrounding the proposed 2013/2014 Energy Bill.

3.1 A smart meter roll out

Following the 2008 Energy Bill, 'smart metering' has emerged as a key government strategy to advance a low carbon energy system by reducing overall demand for energy and promoting greater demand side flexibility which, it is argued, will reduce the overall investment costs of the transition and facilitate the development of a 'smarter' operation of the upstream distribution and transmission infrastructure which sees a shift in demand at peak periods and a potential reduction in the need for extra capacity on the system. The section below focuses on how a government mandated national roll-out of domestic smart meters has come about and how it is envisioned that the process will proceed throughout the 2010s.

Meters have of course been part of electricity systems for many years as a means of monitoring customer demand and avoiding theft. Key metering services that need to be provided are meter provision, meter operation, along with meter reading and information processing (Haney et al., 2011). The majority of the current meter stock in the UK are known as 'basic' meters which '…record consumption cumulatively and are read manually', which is 'often based on estimates' (Haney et al., 2011). Smart meters (SMs) refer to any form of metering which deviates from this 'basic' model in order to provide real-time information to suppliers and/or consumers, typically involving more accurate meter readings and at more regular intervals.

During the period following privatisation and the introduction of liberalisation reforms, the energy regulator, Ofgem, sought to deregulate metering services provision with a view to introducing competition, primarily as a means of developing the retail market for electricity (and gas), but also to promote innovation in metering service provision. Competition in the retail market for electricity was introduced on a phased basis: Initially large industrial and commercial customers were given the option to choose their supplier, and eventually in 1998, full retail competition was introduced affecting both domestic and non-domestic customers.

With a duty 'to protect the interests of consumers, wherever appropriate by promoting effective competition' (Ofgem, 2003: p.1), the energy regulator began to consider the liberalisation of the market for metering services – an estimated value of £800m per annum (Ofgem, 2001). In 2001, Ofgem set out its long term strategy for metering (Ofgem, 2001): In relation to the provision of metering services, the stated aim was "to enable shippers, suppliers and customers to exercise choice over how they obtain metering and meter reading services and to separate metering from monopoly transportation and distribution businesses" (*ibid*, p. 10), with the expectation that this will "reduce the cost of providing existing services". Underpinning this was a clear market based principle that customers "would be better served by more effective competition, which would reduce costs and promote innovation" (*ibid*, p.1).

In 2003, full competition was introduced in the sector (2004 for gas) with the statutory obligation on distribution companies to provide metering services eventually being removed in 2007. Ultimately, as Ofgem stated in their 2006 Domestic Metering Innovation document (Ofgem, 2006), the regulator sought to make retail companies responsible for metering, with decisions being based on commercial grounds, thus forcing companies to innovate, improve service standards and 'shop around' for the best prices on behalf of customers. It was envisioned that over time this would lead to the diffusion of smart meters as companies seek to attract customers by improving their overall service offering.

However, since the emergence of low carbon agenda during the late 2000s, there has been a shift away from a pure market model which had shaped metering policy in the UK. As the 2008 Energy Act passed through parliament, government proposed a coordinated national roll out of SMs 'in domestic households' and 'at small and medium non-domestic (business and public sector) sites' (DECC, 2009) to be completed by 2020. This would, according to the Department of Energy and Climate Change (DECC), 'provide accurate real time information on energy consumption' and 'both change our energy habits and provide an essential stepping stone to smart grids in the future' (DECC, 2009: p.5). This government intervention of course has had significant implications for the previous strategy espoused by the regulator, where smart metering would be left to the market to deliver. However, although the national roll-out has signalled a change from the competitive model which OFGEM had been advocating, the strategy is still underpinned by a market rationality in one key respect, the supplier-led roll-out. Since the introduction of liberalisation electricity generation and retail are competitive activities and therefore suppliers compete for customers in the marker. Transmission and distribution on the other hand are still regarded as non-competitive and these network companies are regulated as natural monopolies. This implies that rather than an area-based distribution company led rollout where costs are passed through to the customer on a regulated basis, as has occurred in other European countries, retail companies will be responsible for delivering the meters to their customers, although now mandated to do so. Following the publication of a number of consultation and strategy documents (DECC, 2010, DECC, 2011, DECC, 2009), DECC have proposed a 'supplier hub model' with a centralised communication provider. Here 'gas and electricity supply companies will have responsibility for the provision of smart meters' but 'a single provider will be appointed centrally to provide communications services to and from meters' (DECC, 2009: p.19).

Some have argued that the companies who operate the distribution grids, (distribution network operators (DNOs)), rather than suppliers, should be at the centre of smart metering strategy as they would be best placed to utilise the real time information to improve capacity management across the networks (CSE, 2012), and that this more regulated approach could reduce the costs of meter installation (Jennings, 2013). Also, due to the retail led strategy, questions have been raised about the compatibility of the 'supplier-hub' principle with the broader transition towards 'smarter grids'; in particular what level of functionality the meters themselves will have and the degree to which different parties across the value chain will have access to customer data (CSE, 2012, NAO, 2011). Since the announcement of the roll out there has been efforts to respond to these criticisms, in particular with the establishment of the cross-industry Smart Metering Design and Implementation Coordination Groups which were set up as part of DECC's Smart Metering implementation programme.

In reading policy documents relating to the roll-out, its main purpose is sometimes unclear; whether this is for demand reduction, demand management at peak, or for more accurate billing. Due to the nature of the roll-out in the UK, there is some concern that suppliers, rather than customers, will be the main beneficiaries[2] as there will likely have less operational costs in meter reading and dealing with customer inquiries (CSE, 2012). The main justification from customer point of view has been that more accurate energy use information will enable customers to reduce their consumption by up to 2.8% annually for electricity customers (2% for gas) (DECC, 2013). However a recent report from the National Audit Office (NAO, 2011) questioned these assumptions, which are largely based on international trials, as they 'may not be relevant to Great Britain due to differences in climates and cultures of energy use, and evidence on sustained behaviour change is limited' (*ibid*: p.6).

3.2 Electricity Market Reform (EMR) proposals

The second policy area which we discuss are recent proposals by government to change wholesale power market, primarily to incentivise investment in 'low carbon' generation such as nuclear, carbon capture and storage and wind power. In the coming decade there will be a need for the more rapid deployment of renewable and other low carbon forms of generation if the UK is to meet its renewable energy and climate change targets. It is envisioned that by 2020 at least 30% of electricity generation will need to be from

[2] DECC estimates that the programme will cost £11.3bn with an overall benefit of £18.6bn from 'efficiency savings and environmental benefits' (NAO, 2011)

renewable sources (HM Government, 2011), and analysis from the government's independent advisory body, the Committee on Climate Change (CCC), indicates that a near total decarbonisation of the power sector by 2030 will be necessary (CCC, 2010). A key concern for UK government in the short term future is that as many of the older coal and nuclear plants which were build during nationalisation are due to come off stream in the coming decade, in part due to environmental legislation on local air quality[3], resulting in falling spare capacity on the system (Ofgem, 2012) and a potential threat to energy security. At the same time, increasing wholesale gas prices are leading to concerns over affordability of domestic gas and electricity supplies. This need for investment to meet climate change targets and ensure energy security and affordability is now prompting government to intervene in the liberalised market for power generation to ensure that these broader societal objectives are met.

As a response to these issues the UK government has recently announced proposals for electricity market reform (EMR) as part of a new Energy Bill. Similar to the smart metering case, this signifies a more interventionist role for government than was previously the case when investment in electricity generation technologies was an outcome of investor responses to market signals. At the root of the problem with the liberalised market structure has been the fact that investment in combined cycle gas turbine plants (CCGT) has been the investment of choice due to its lower capital cost relative to low carbon options (nuclear, renewables and CCS) and its ability to be flexible and respond to fluctuations in the wholesale gas price. While CCGT is a lower carbon option than coal for example, it is generally accepted that if the UK is to meet its climate and renewable objectives CCGT can only be used on an intermittent basis, providing flexible peaking plant at times of low wind (CCC, 2010).

The electricity market in the UK, known as BETTA[4], operates on a rolling half-hour basis where the vast majority of trading is conducted bilaterally between retail companies who

---

[3] Approximately 12GW of coal and oil fired generation will come off stream by the middle of this decade due to the EU's Large Combustion Plant Directive. Also a number of nuclear plants are nearing the end of their operation lives and will also need to come off the system.

[4] British Electricity Trading and Transmission Arrangements

sell to customers and generators. Suppliers are incentivised to procure adequate volumes to meet their demand and generators face penalties if they do not input the agreed about of power into the grid. Partly in order to overcome these risks the large energy companies in the UK have adopted vertically integrated corporate structures and as a result the market is now dominated by six large utilities who both generate and sell power to customers – the 'big six'. A key motivation behind government efforts to reform the market structure has been to overcome barriers to investment in low-carbon generation and address the additional risks that they face in a fossil fuel dominated system. Due to the structure of the UK market and the large amounts of CCGT on the system, electricity prices are closely linked with fluctuations in the gas price, therefore investors in CCGT have some degree of certainty as to their future returns as price fluctuations can be passed on to the customer. The same is not the case for higher capital cost low carbon generators whose costs are more associated with the one off initial capital investments rather than ongoing fuel costs and therefore require a greater degree of certainty over long term electricity prices to make an adequate return (For a more detailed discussion see: Gross et al., 2007).

The central proposal in EMR is to introduce contracts for difference (CfD), whereby a fixed 'strike price' is determined for the different low carbon technologies (nuclear, CCS, onshore and offshore wind) and this consistent strike price is set against the average annual wholesale price set by the market (a fluctuating reference price). Low carbon generators who have entered into a contract will receive the market price for their electricity plus a top up – the difference between the strike process and the market price – and in theory will have more certainty over long term electricity prices. Along with the CfD proposal other key aspects of the EMR package of policy instruments include a capacity mechanism, giving an additional and reliable revenue stream to operators of flexible gas plant which will be used on an irregular basis but will be important for energy security in a high wind future. The third policy instrument is an Emissions Performance Standard (EPS) which sets a limit of 450g/kWh for all new fossil fuel plant with the purpose of ensuring that there will be no more unabated coal plants built in the UK. Also, due to the poor performance of the European Emissions Trading Scheme, as part of the overall policy package the UK Treasury will introduce an artificial floor on the carbon price for electricity generation. As part of the

2011 Finance Act a carbon price floor is to be introduced in 2013 at approx £15.70/tCO2, rising to £30/tCO2 in 2020 and £70/tCO2 in 2030.

Clearly the nature and content of the proposals are more complex that presented here (For an overview see: DECC, 2012) and at the time of writing the Energy Bill is undergoing parliamentary scrutiny. It is therefore difficult to assess the extent to which the details of the proposals will change and their potential future impact. The first CfD for a new nuclear plant at Hinkley Point is currently being negotiated between government and the French energy company EDF, who, it is reported, is demanding a 30-40 year contract with a strike price in the region of £100/MWh.

Much of the debate in policy, academic and media circles has been encapsulated by the House of Commons Energy and Climate Change (House of Commons, 2012) who criticised a number of aspects of the 2011 Draft Energy Bill:

- That uncertainty in the level of strike price to be offered to different low carbon technologies and a lack of detail on the way in which it will be determined was delaying investment.
- That there was no decarbonisation target for the electricity sector for 2030 as recommended by the CCC.
- That caps imposed by the UK Treasury on the total levels of revenue available to finance the contracts for difference could adversely affect investment decisions.

Regardless of one's views on these issues and debates, similar to the smart metering example, the proposals are characteristic of increasing government intervention in how investment decisions will be made, but important aspects of the proposals such as the two-sided contract design retain a significant reliance on market mechanisms.

4 Analysing governance change

In this part of the paper we return to our socio-technical framing outlined in section two to analyse in more depth the cases outlined above. In each of the cases we have seen how contemporary energy governance is characterised by a complex interaction of technologies, institutions and actors. In order to account for this the first section below draws on the concept of socio-technical regimes to explore how a realignment of incumbent actors and institutions is taking place to orientate the low carbon transition towards its existing resources and capabilities. Following this we focus in more detail on government and market actors and how their logics, or framings of a low carbon transition, are becoming intertwined and enmeshed as part of a process of hybridization.

4.1 Regime Adaptation

As briefly discussed in the introduction, a central research question within the socio-technical transitions literature has been how to redirect environmentally intensive 'regimes' such as energy supply, transport, water and food systems, towards more sustainable long term trajectories (Markard et al., 2012, Smith et al., 2010). Regimes in this sense are complex configurations of technical artefacts, institutional frameworks, business models and social practices (Bolton and Foxon, 2011, Foxon, 2011, Geels, 2004). The transition to more sustainable socio-technical regimes presents a challenge as over time these social and technical dimensions have coevolved in a mutually reinforcing pattern, resulting in highly structured ways of organising and delivering essential societal services. Unruh (2000) characterises this as a 'lock-in' of technology and institutions which is reinforced by increasing returns to scale and adoption and path dependent processes which limit the agency of actors at the firm and policy level, resulting in incremental change and relatively predictable patterns of behaviour and decision making.

This framing of socio-technical regimes has clear relevance to national electricity systems and the processes of change outlined in the previous section. Mature electricity systems such as in the UK are based on centralised fossil-fuel generation and large scale centralised technologies and over the years regime resources and capacities have become associated with this 'dominant design'. It is unsurprising therefore that the current regime will seek to adapt and orientate the low carbon transition towards centralised and large scale solutions and the types of technologies which can benefit most from its resources and capacities.

In this light contemporary energy policy dynamics could be seen as a protective or defensive stance as powerful actors such as large utility companies and national governments who have traditionally exerted a dominant influence over the energy regime seek to protect and extend their interests. In order for the envisioned smart meter roll out and the proposals for electricity grid decarbonisation to succeed, a coordinated programme of infrastructure investment will be required which is likely to require vast amounts of upfront capital and techno-economic expertise which has historically been the domain of the incumbent energy companies. National government too is part of this process in providing the overarching regulatory framework within which such investments can take place and be profitable over such long timescales. Therefore, regime actors in this case are seeking to respond to new selection pressures - the climate change agenda and concerns over energy security - and are framing the low carbon transition as an investment challenge. The policy imperative is to facilitate large scale investment programmes, and in the case studies we have seen that this is being achieved by government intervening in the market to realign investment risk between private investors and customers through the EMR, and by coordinating smart meter investments through a mandated national roll out.

However the success or otherwise of this regime adaptation in maintaining existing power structures and relations is as yet uncertain. Historical studies of previous regime transitions have shown that unexpected and disruptive innovations which emerge from outside the mainstream regime in niches can challenge regime competencies and value chains and derail established trajectories of socio-technical change (Geels, 2002). Smith et al. (2005) point to three key factors which influence regime adaptation and transformation: how selection pressures are articulated by regime members, whether regime members possess the resources and capacities necessary for transformation, and finally the extent to which regime responses are coordinated and coherent. They argue that the adaptive capacity of a regime is 'a function of the availability of resources and how they are coordinated' (*ibid*: p.1492) and this is a key determinant of the pathway or 'transition context' which emerges. Regimes with a high adaptive capacity are well resourced and respond in a highly coordinated manner to selection pressures. What is likely to emerge in this context is a process of '*Endogenous Renewal*' where regime members 'find ways of responding to perceived competitive threats to a regime' (p.1500).

Geels and Schot (2007) present an alternative understanding of regimes and pathways which is based on multi-level interactions between macro level landscapes, meso regimes and micro level niches. While the Smith et al. approach focuses on internal regime capacity and resources, Geels and Schot are more focused on nature and timing of multi-level interactions. Key factors which influence the ability of a regimes to persist are the timing of multi-level interactions - whether niche innovators can take advantage of windows of opportunity presented by landscape level pressure on regimes - and the nature of those interactions - the extent to landscape changes have 'stabilising effects on the regime' and niche innovations are competitive or can be co-opted into regime structures in some way - see Shackley and Green (2007) for an application to the UK context. A typology of pathways based on combinations of these variables is presented. In their *transformation* pathway for example regimes slowly adapt to landscape level selection pressures over time because innovators at the niche level have not developed sufficient resources and transformational capacity to influence change in any meaningful way. As a result 'new regimes grow out of old regimes through cumulative adjustments and reorientations' (ibid: p. 407). The extent to which the UK centralised electricity regime can achieve this is discussed further in section 5.1 below.

4.2 Hybrid pathways and logics

The second approach we adopt to understand and unpack contemporary energy policy dynamics in the UK focuses more on the different actors and actor groups within the system - how they formulate different visions or imaginaries of a low carbon energy system and how they begin to interact within the energy transition 'action space'[5]. This approach has been developed in a number of publications (Foxon et al., 2010, Foxon, 2013) as a way of exploring prospective low carbon transition pathways to 2050, with each pathway constructed around the framings or 'logics' of three actor groups – government, market and civil society. These 'different types of actors typically follow different underlying 'logics' that frame their view of the world and of other actors, and seek to 'enrol' others into their logic' (Foxon, 2013):

Central Co-ordination "argues for a dominant role for the direct co-ordination of energy systems by national government actors to deliver energy policy goals", the *Market Rules*

[5] The action space approach was originally developed by Jacquie Burgess and Tom Hargreaves at the University of East Anglia.

pathway follows the logic "that energy policy objectives are best achieved by market actors freely interacting within a high-level policy framework", the logic of *Thousand Flowers* is "that energy systems should meet the needs of citizens, who should therefore take a leading role in the decisions relating to how the energy system operates" (Foxon, 2013). Foxon (2013) explores each of these ideal type logics and discusses how they might lead to alternative socio-technical configurations of a low carbon energy system to 2050.

Ideal type pathways are a heuristic device and of course do not represent in any way the reality of socio-technical change which is complex and messy. Rydin et al.(2013) note that a key aspect of contemporary energy politics is the coexistence and coming into contact of different pathways; they are 'neither static not mutually exclusive, but instead represent a range of options that might overlap, reinforce, or clash with each other as they either are rolled out and upscaled, or disrupted and disconnected' (p.638). The action space represents the 'arena' in which different framings, or 'logics', interact[6] and is characterised by different spaces of reproduction and transformation, infrastructure investment being one of these. Here, following Blyth (2002), we argue that during periods of crisis and structural uncertainty action spaces become opened up as new ideas about transformational change become influential in challenging dominant paradigms and regimes. These windows of opportunity or 'branching points' (Foxon et al., 2013) are typically brief, after which uncertainty is reduced and the trajectory of system change once again becomes more predictable. In order to account for these different phases of socio-technical change characterised by punctuated equilibria both contextual/actor-centric understandings, such as the action space and logics approach, and structural/mechanistic frameworks, such as regimes and multi-level interactions, are therefore required.

Looking at contemporary issues around energy policy and investment in the UK electricity infrastructure it is perhaps no longer a case of one logic dominating, as was the case under nationalisation and since privatisation, rather a hybrid between the *central coordination* and *market rules* pathways is emerging. Recognising that the market based model was not

[6] A similar approach has been developed by Jørgensen (2012) who introduces the concept of 'arenas of development' as an actor based framing of socio-technical transitions which he contrasts with the notion of regimes and multi-level interactions.

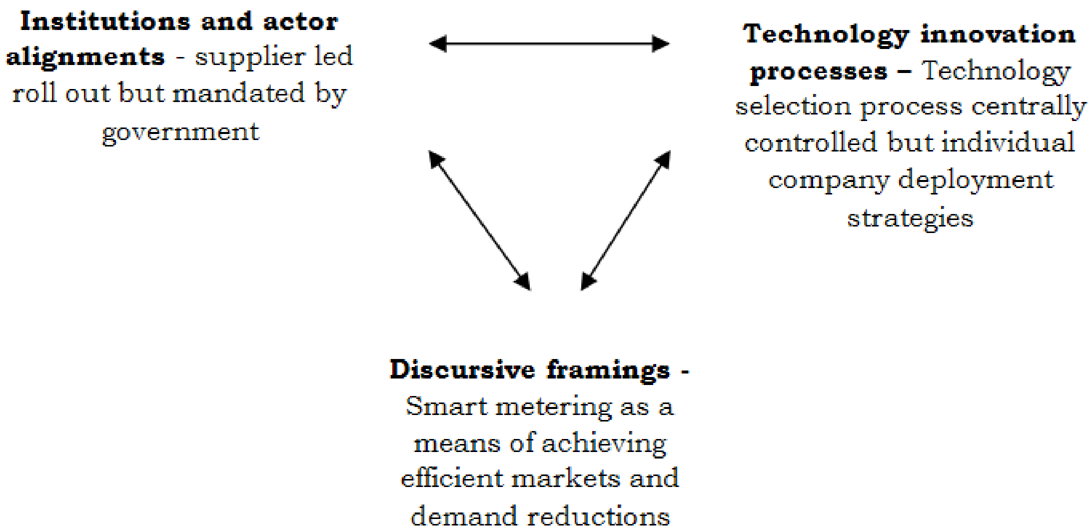
capable of delivering the type and speed of investment required, the realignment has seen a new role for government in providing the necessary industry coordination and in altering the investment risk-returns ratio to make long term capital investments in the electricity system more attractive. In both cases we see a new form of interdependency between public and private actors as government, while intervening in a more direct way to pursue its goals of long term decarbonisation and energy security, is still reliant on private actors and market processes to deliver its energy policy priorities.

This is in line with Fudge et al's (2011) argument that while recent years has seen a rise in prominence of climate change and energy security concerns, there has not been a wholesale abandonment of market principles and a shift to a new energy governance paradigm based on ideological grounds. Rather it has been characterised by the 'absence of a distinct ideological project' as 'policies and practices remain conditioned by existing practices, particularly by the legacy of the market' (p.301).

Hybridization as part of an action space dynamic is a cross-fertilization of the market and government logics and forms the underlying mechanism of the process of regime adaptation outlined previously. These actors share a common framing of the low carbon transition - an investment challenge - and are attempting to built this into existing institutions through a process of 'inter-paradigm borrowing' (Kuzemko, 2013). This will enable market actors to retain their central role in the energy transition and will offset the need for government to expend resources and political capital in returning to some form of a pre-privatisation model of energy governance.

In the diagram below we reflect on the smart metering example and attempt to characterise some of the key aspects of the hybridization process which incorporates actors and their logics, institutions, policy instruments and innovation processes. In the smart metering case hybridization is an interactive process involving a new actor and institutional alignment which sees top down government coordination but some degree of market autonomy in deployment strategies. An interesting aspect of this is how the framing of technology has changes throughout the process: In each of the cases there has been some degree of 'interpretive flexibility' (Pinch and Bijker, 1987) as technologies become reframed as contributing to both the effectiveness of the market and long term decarbonisation, examples include the labelling of nuclear power as a low cost 'low carbon' technology, and the reframing of smart metering as a means to achieve demand reductions.

Figure: An interactive process of hybridisation – the smart metering case



Currently this action space dynamic is at an early stage and occurring in specific technology fields and policy arenas where perhaps these crossovers are most apparent. This may evolve further and spread across all energy policy domains, signalling a branching point away from the market led pathway, alternatively it may be a temporary hybrid designed to achieve investment in a specific set of strategic low carbon technologies and once this is achieved we will see a reversion to a market logic. The UK government for example does envisage that sometime during the 2020s strike prices under the EMR will no longer be determined by the secretary of state, but through an auction process where low carbon technologies begin to compete against one another. However, the degree to which this hybrid is temporary is questionable: The EMR will see a re-regulation of the low carbon electricity market, a market which is due to increase dramatically in size over the coming decades, and therefore despite the continuing rhetoric around the importance of market principles in energy policy, such measures may culminate in a permanent deviation from the liberalised trajectory (Keay, 2012).

5 Policy Implications

In this section we draw on the analysis above to interrogate and inform ongoing energy policy debates in the UK - we ask three questions of contemporary UK energy governance:

5.1 Regime learning or lock-in?

An important question arising from our discussion of regime adaptation in section 4.1 is the extent to which this is a process of learning which will enable the centralised regime to deliver low carbon objectives, or whether it will create barriers to necessary structural changes and lock-in.

The cases outlined above do illustrate that the incumbent regime does possess the capacity to evolve and recent changes to the EMR proposals and smart meter roll out programme also signal some capacity to learn and a willingness to tweak initial proposals. Also, the EMR package could be viewed as a flexible set of instruments which address a number of policy priorities and which can be adjusted as circumstances change and uncertainty about the low carbon future is reduced. This process of incremental change may create consensus between powerful actors within the regime who have significant capacity and resources, potentially culminating in an endogenous renewal. It has historically been the case that investment programmes at the scale and speed envisioned have been delivered by a relatively narrow set of government and industry actors, either through direct state control or through some form regulation which provides certainty and guaranteed rates of return to private investors.

An alternative view is that while incremental changes to the existing regime may lead to short term gains, in the long term it will be inefficient and stifle innovation as only those low carbon technologies which also contribute to the goal of liberalised energy markets as currently instituted in the UK will be adopted. Learning within the confines of an existing regime and a lack of emphasis on exploring alternatives and nurturing niches may, in the medium and long term, lead to structural barriers to the achievement of a system-wide energy transition. The smart meter case is perhaps applicable here due to the questioning of the market led roll-out and whether it will act as a barrier to the transition towards smarter grids and deeper structural changes to the energy system further down the line.

The literature on path dependency and increasing returns (Arthur, 1989, Arthur, 1994, David, 1985, Pierson, 2000) is informative here as it highlights the danger of making decisions solely based on current economic and social needs rather than long term thinking. For example, the EMR proposals, in seeking to treat all low carbon technologies equally and retain elements of a free market platform, do not recognise that a) different low carbon technologies face different types if risk in the market and b) they are at different stages of development, therefore the one size fits all approach may lock-out many promising renewable technologies which, while not competitive under current market conditions, would be beneficial in the long term.

5.2 Coherent policy outcomes?

Analysing the process of hybridization as an action space dynamic leads us to question whether these logics and objectives are compatible. 'Getting the best of both worlds' in terms of long term decarbonisation and market efficiency may be possible in the early phase of hybridization and may help to create consensus, however, in the long run difficult decisions such as fundamental, but potentially necessary, regulatory reform may be side-stepped. There is some evidence to suggest that a lack of ideological consistency and clarity may be an important defect of such hybrid arrangements. This issue has been highlighted in Kern and Howlett's findings in a review of Dutch energy policy where a similar presence of competing objectives is leading to increasing complexity in policy design and an overall lack of clarity in policy objectives (Kern and Howlett, 2009).

The smart metering case, where suppliers rather than network companies are central to the roll-out, illustrates the dangers of not thinking systemically about the long-term infrastructure needs e.g. the transition towards smarter grids. Focusing on one component innovation such as smart metering, which although may improve the functioning of the market, runs the risk of not laying down the foundations for wider systemic transformation. Multiple policy objectives may be compatible in some areas, e.g. smart metering technology, but to develop a coherent pathway more clarity may be needed on the underpinning logic driving system change, particularly when long term investment in low carbon technologies is required. This lack of clarity may undermine investor confidence in more risky low carbon technologies and potentially lead to a new ‘dash for gas’, thus reinforcing the fossil fuel lock-in.

5.3 Opening up the energy transition action space?

A final point to note is that in this evolving hybrid which is centered on low carbon investment, the role of alternative logics and pathways is poorly articulated. There is a risk that as powerful regime actors reposition themselves within the action space alternative pathways will be marginalised, in particular those which are open to alternative forms of organisation and energy generation/consumption. The *thousand flowers* pathway outlined by Foxon (2013) for example sees a more prominent role for local actors and wider civil society in shaping the energy transition involving a diversity of bottom up solutions and local scale technologies.

There are a number of potential benefits of opening up the action space in this way; for example, enabling local communities and individuals to invest in renewable technologies and to have a stake in the success of the low carbon transition could improve its long term resilience by improving trust and legitimacy in the governance process. Also, engaging with citizens and communities could tap into the potential for creativity and new ways of thinking which exist in wider civil society (Smith, 2012). A better understanding of how changes in social practices beyond narrow economic motivations could help to reduce our energy consumption, potentially offsetting the need for further supply side investments (Shove, 2012)

Although the UK has introduced a feed-in tariff scheme to subsidise small scale renewables, issues such as this are relatively marginal to the mainstream energy policy debates which, as outlined, tend to centre on investment in large scale technological solutions and economic incentives. A more distributed form of governance and decision making will require the articulation of a new logic centered on the need for broad based societal change with objectives more aligned to a diversity of social goals, involving more inclusive and democratic processes of participation and engagement (Chilvers and Longhurst, 2012). In practical terms this would require the creation of new institutional platforms and forms of engagement which open up spaces for agency, particularly at the local scale, and which enable non-market actors to have a financial stake in the low carbon future.

6 Conclusions

This paper sought to operationalise insights and concepts from the socio-technical systems literature to analyse and unpack contemporary energy governance in the UK, broadly relating to the energy policy 'trilemma' of affordability, decarbonisation and energy security. Focusing on energy policy initiatives designed to coordinate and stimulate investment in smart metering and electricity generation technologies, we charted how multiple policy objectives are interacting as part of a complex web of technologies, actors and institutions. What is emerging is a process of regime adaptation driven by powerful regime actors who are seeking to align the objectives of market liberalisation and electricity system decarbonisation. Rather than replacing the market and reverting to a traditional model of wholesale state control over the energy system, a hybrid logic is emerging. In this context government intervention is more subtle e.g. the development of contracts for difference for low carbon generation and the coordination of utility company roll-out strategies for smart metering technologies. This cannot be characterised as a uniform process across all energy policy arenas and technology fields, and may be a temporary arrangement to deliver a programme of specific investments with a later reversion to a market led pathway.

We argued that this type of socio-technical approach and system framing can be a useful lens for the analysis of ongoing processes energy governance, particularly during a period of fundamental uncertainty regarding innovation outcomes, actor strategies, ideologies and institutional change. While we have developed an understanding of contemporary governance processes, an important next step will be to analyse how these processes can be improved and built upon, for example, whether a more strategic cross-departmental government response is required, how reflexivity and learning can become more central to the policy processes and how governance can be opened up to a wider range of civil society actors.

References

ARTHUR, W. B. 1989. Competing Technologies, Increasing Returns, and Lock-In by Historical Events. *Economic Journal,* 99**,** 116-131.

ARTHUR, W. B. 1994. *Increasing Returns and Path Dependance in the Economy,* University of Michigan Press Ann Arbor.

BLYTH, M. 2002. *Great Transformations: Economic Ideas and Institutional Change in the Twentieth Century,* New York, Cambridge University Press.

BOLTON, R. & FOXON, T. 2011. Governing Infrastructure Networks for a Low Carbon Economy: Co-Evolution of Technologies and Institutions in UK Electricity Distribution Networks. *Competition and Regulation in Network Industries,* 12**,** 2-26.

BOSTON, A. 2013. Delivering a secure electricity supply on a low carbon pathway. *Energy Policy,* 52**,** 55-59.

CCC 2010. The Fourth Carbon Budget Reducing emissions through the 2020s. Committee on Climate Change, London.

CHILVERS, J. & LONGHURST, N. 2012. Participation, Politics and Actor Dynamics in Low Carbon Energy Transitions. University of East Anglia: http://www.3s.uea.ac.uk/low-carbon-energy-transitions-workshop.

CSE 2012. The smart metering programme: a consumer review. A report to Which? by the Centre for Sustainable Energy.

DAVID, P. 1985. Clio and the Economics of QWERTY. *American Economic Review,* 75**,** 332-337.

DECC 2009. A Consultation on Smart Metering for Electricity and Gas.

DECC. 2010. *Smart Metering Implemnentation Program Prospectus.*

DECC. 2011. *Smart Metering Implementation Program: Response to Prospectus Consultation.*

DECC 2013. Smart meter roll-out for the domestic and small and medium non-domestic sectors (GB). Department of Energy and Climate Change, London.

FOXON, T. 2011. A coevolutionary framework for analysing a transition to a sustainable low carbon economy. *Ecological Economics,* 70**,** 2258-2267.

FOXON, T. J. 2013. Transition pathways for a UK low carbon electricity future. *Energy Policy,* 52**,** 10-24.

FOXON, T. J., HAMMOND, G. P. & PEARSON, P. J. G. 2010. Developing transition pathways for a low carbon electricity system in the UK. *Technological Forecasting and Social Change,* 77**,** 1203-1213.

FOXON, T. J., PEARSON, P. J. G., ARAPOSTATHIS, S., CARLSSON-HYSLOP, A. & THORNTON, J. 2013. Branching points for transition pathways: assessing responses of actors to challenges on pathways to a low carbon future. *Energy Policy,* 52**,** 146-158.

FUDGE, S., PETERS, M., MULUGETTA, Y. & JACKSON, T. 2011. Paradigms, Policy and Governance: The Politics of Energy Regulation in the UK Post-2000. *Environmental Policy and Governance,* 21**,** 291-302.

GEELS, F. W. 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy,* 31**,** 1257-1274.

GEELS, F. W. 2004. From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy,* 33**,** 897-920.

GEELS, F. W. & SCHOT, J. 2007. Typology of sociotechnical transition pathways. *Research Policy,* 36**,** 399-417.

GROSS, R., BLYTH, W. & HEPTONSTALL, P. Investment in electricity generation: the role of costs, incentives and risks. 2007 Imperial College, London.

HANEY, A. B., JAMASB, T. & POLLITT, M. 2011. Smart metering: technology, economics and international experience. *In:* JAMASB, T. & POLLITT, M. (eds.) *The Future of Electricity Demand: Customers, Citizens and Loads.* Cambridge: Cambridge University Press.

HELM, D. 2003. *Energy, the state, and the market: British energy policy since 1979,* Oxford, Oxford University Press.

HELM, D. 2012. *The Carbon Crunch: How We're Getting Climate Change Wrong - and How to Fix it*, Yale University Press.

HM GOVERNMENT 2011. The Carbon Plan: Delivering our Low Carbon Future. *In:* DEPARTMENT OF ENERGY AND CLIMATE CHANGE (ed.).

HOUSE OF COMMONS 2012. Draft Energy Bill: Pre-legislative Scrutiny - Volume I. Energy and Climate Change Committee, London

HUGHES, T. 1983. *Networks of power : electrification in Western society, 1880-1930* Baltimore, Johns Hopkins University Press.

JENNINGS, M. G. 2013. A smarter plan? A policy comparison between Great Britain and Ireland's deployment strategies for rolling out new metering technologies. *Energy Policy*.

JØRGENSEN, U. 2012. Mapping and navigating transitions - The multi-level perspective compared with arenas of development. *Research Policy,* 41**,** 996-1010.

KEAY, M. 2012. Death by a thousand regulations: the new energy bill. Oxford Institute for Energy Studies.

KERN, F. 2012. Using the multi-level perspective on socio-technical transitions to assess innovation policy. *Technological Forecasting and Social Change,* 79**,** 298-310.

KERN, F. & HOWLETT, M. 2009. Implementing transition management as policy reforms: a case study of the Dutch energy sector. *Policy Sciences,* 42**,** 391-408.

KUZEMKO, C. 2011. UK Energy Governance in the Twenty-first Century: Unravelling the Ties that Bind. PhD Thesis. Politics and International Studies, University of Warwick.

KUZEMKO, C. 2013. Understanding the Politics of Low Carbon Transition. IGov Working Paper 1, University of Exeter: http://projects.exeter.ac.uk/igov/wp-content/uploads/2013/01/DOWNLOAD-WP1-Understanding-the-Politics-of-Low-Carbon-Transition.pdf.

LAW, J. 2009. Actor network theory and material semiotics. *In:* TURNER, B. (ed.) *The New Blackwell Companion to Social Theory.* Blackwell Publishing.

LOVELL, H. 2007. Exploring the role of materials in policy change: innovation in low-energy housing in the UK. *Environment and Planning A,* 39**,** 2500-2517.

MARKARD, J., RAVEN, R. & TRUFFER, B. 2012. Sustainability transitions: An emerging field of research and its prospects. *Research Policy,* 41**,** 955-967.

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

NAO 2011. Preparations for the roll-out of smart meters. Report by the Comptrollerer and Auditor Genereral.

OFGEM 2001. Ofgem’s strategy for metering: A consultation paper. Office of Gas and Electricity Markets, London.

OFGEM 2003. Competition in Electricity Metering Services - Industry Guidance V.1.1.
OFGEM 2006. Domestic Metering Innovation - Decision Document.
OFGEM 2012. Electricity Capacity Assessment. Office of Gas and Electricity Markets, London.
PIERSON, P. 2000. Increasing Returns, Path Dependence, and the Study of Politics. *The American Political Science Review,* 94**,** 251-267.
PINCH, T. & BIJKER, W. 1987. The Social Construction of Facts and Artifacts: Or How the Sociology of Technology Might Benefit Each Other. *In:* PINCH, T., BIJKER, W. & HUGHES, T. (eds.) *The Social Construction of Technical Systems.* Cambridge: MIT Press.
RIP, A. & KEMP, R. 1998. Technological Change. *In:* RAYNER, S. & MALONE, E. (eds.) *Human Choice and Climate Change.* Ohio: Batelle.
RYDIN, Y., TURCU, C., GUY, S. & AUSTIN, P. 2013. Mapping the coevolution of urban energy systems: pathways of change. *Environment and Planning A,* 45**,** 634-649.
SCRASE, I. & MACKERRON, G. 2009. *Energy for the Future: A New Agenda,* London, Palgrave Macmillan
SHACKLEY, S. & GREEN, K. 2007. A conceptual framework for exploring transitions to decarbonised energy systems in the United Kingdom. *Energy,* 32**,** 221-236.
SHOVE, E. 2012. Energy Transitions in Practice: The Case of Global Indoor Climate Change. *In:* VERBONG, G. & LOORBACH, D. (eds.) *Governing the Energy Transition: reality, illusion.* Routledge.
SMITH, A. 2012. Civil society in sustainable energy transitions. *In:* VERBONG, G. & LOORBACH, D. (eds.) *Governing the Energy Transition: reality, illusion.* Routledge.
SMITH, A., STIRLING, A. & BERKHOUT, F. 2005. The governance of sustainable socio-technical transitions. *Research Policy,* 34**,** 1491-1510.
SMITH, A., VOß, J.-P. & GRIN, J. 2010. Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy,* 39**,** 435-448.
TESCHNER, N., GARB, Y. & PAAVOLA, J. 2013. The Role of Technology in Policy Dynamics: The Case of Desalination in Israel. *Environmental Policy and Governance,* 23**,** 91-103.
UNRUH, G. C. 2000. Understanding carbon lock-in. *Energy Policy,* 28**,** 817-830.
VERBONG, G. & LOORBACH, D. 2012. Introduction. *In:* VERBONG, G. & LOORBACH, D. (eds.) *Governing the Energy Transition: Reality, Illusion or Necessity?* : Routledge.