# Transition pathways for a UK low carbon energy system: exploring different governance patterns

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## Abstract

This paper describes outline transition pathways for a low carbon energy system in the UK, which are currently being developed in a collaborative research project, involving leading UK engineers, social scientists and policy analysts. The pathways are exploring different governance patterns, relating to the roles of central government, market actors and structures, and civil society, in relation to both centralised and decentralised systems for meeting energy service demands. This work is using a conceptual and analytical framework for specifying transition pathways that relates the multi-level perspective of landscape, regime and niche levels to recent work on technological innovation systems. The specification of the pathways draws on earlier work on UK energy and international energy scenarios, initial interviews with 'gatekeepers' from the UK energy policy and industry communities, and useful insights from a workshop with invited stakeholders from the policy-making, industry and academic communities, held in November 2008. The pathways explore how social and political issues, such as public acceptability of different technologies and institutional changes, the mixture of short-term and long-term drivers and influences affecting policy-making, and the strategies of large and small firms, interact or 'co-evolve' with present and expected future changes in technologies.

**Key words**: *Transition pathways, governance patterns, energy policy, co-evolution of technologies and institutions*

## 1. Introduction

This paper contributes to the theme of the Conference by describing current ongoing work applying socio-technical transitions theory to understanding pathways to a low carbon energy system in the UK. This work is being undertaken within a collaborative research project, involving leading UK engineers, social scientists and policy analysts, supported by the UK EPSRC and the energy company E.ON UK (Foxon et al., 2008a,b, 2009). The project aims to (a) to learn from past transitions to help explore future transitions and what might enable or avoid them; (b) to design and evaluate transition pathways towards alternative socio-technical energy systems for a low carbon future; and (c) to understand and where appropriate model the changing roles, influences and opportunities of actors in the dynamics of transitions.

Section 2 of the paper describes the multi-level perspective for analysing socio-technical transitions, based on interactions between three levels: *niches, socio-technical regimes,* and *landscapes* (Rip and Kemp, 1998; Geels, 2002, 2005a). In our work, we are seeking to understand and facilitate potential transition pathways for the future evolution of UK energy systems towards a low carbon regime. In order to do this, we combine elements of historical analysis using this multi-level perspective, which inform how the broad, long-term sweep of dynamics arises out of interactions between actors, institutions and infrastructures, with elements from transition management, which show how purposeful actions by actors within systems can give rise to changes in institutions and infrastructures. Our methodology for developing transition pathways is outlined in Section 3. The pathways are used to explore the co-evolution of technologies, governance systems/institutional frameworks, business strategies and user practices for plausible future evolution of UK energy systems.

A key focus of the transition pathways is to investigate how different governance processes could affect transitions, by examining how the interactions between choices made by different actors within the system, including national and local policy-makers, large firms and new entrants, financial investors and end-users, give rise to changes to the system. These actors have a range of individual and social goals, including the supply and provision of energy services at reasonable costs, maintaining security of supply, and contributing to wider social and environmental aims, which may often be conflicting in any particular decision process. Section 4 sets out the idea of developing an 'action space' representation of interactions between these actors, giving rise to different governance patterns, and so to different types of transition pathways. Section 5 sets out our initial thinking on developing outline transition pathways for UK energy systems, using this representation. Section 6 concludes the paper by setting out the next steps to be undertaken in the research project to analyse and explore these pathways.

## 2. Multi-level perspective on socio-technical transitions

An ongoing research programme on *transitions in socio-technical systems* has been pioneered by Dutch researchers and generated significant international attention and interest (Elzen et al., 2004a; Geels, 2005a). This draws on earlier work on technology and innovation studies, evolutionary economics, and sociology and institutional theory.

This research combines technical, social and historical analysis of and insights into past and current transitions, developing and using an analytical framework based on interactions between three 'levels': *technological niches, socio-technical regimes,* and *landscapes* (Geels, 2002). The *landscape* (macro) level represents the broader political, social and cultural values and institutions that form the deep structural

relationships of a society and only change slowly. The *socio-technical regime* (meso level) reflects the prevailing set of routines or practices used by actors, which create and reinforce a particular technological system, including "engineering practices; production process technologies; product characteristics, skills and procedures […] all of them embedded in institutions and infrastructures" (Rip and Kemp, 1998). Whereas the existing regime generates incremental innovation, radical innovations are generated in micro-level *niches*, which are spaces that are at least partially insulated from 'normal' market selection in the regime, for example, specialised sectors or market locations. Niches provide places for learning processes to occur, and space to build up the social networks that support innovations, such as supply chains and user-producer relationships. Transition pathways arise through the dynamic interaction of technological and social factors at these different levels.

Research under the transitions approach has developed along three main lines:

***The historical dynamics of transitions***

Firstly, the multi-level perspective is used as a framework within which the historical dynamics of transitions may be analysed, enabling further refinement of the multi-level perspective. The historical dynamics within the Dutch electricity system from 1960 to 2004 was analysed by Verbong and Geels (2005). Other analyses have examined transitions from sailing ships to steam ships (Geels, 2002); from horse-drawn to automobile transport systems (Geels, 2005b); from cesspools to sewer systems (Geels, 2006); and biogas development in Denmark (Geels and Raven, 2007).

***Transition management***

Secondly, the transitions approach has been used as a basis for developing *'transition management'*. This is a process of governance seeking to steer or modulate the dynamics of transitions through interactive, iterative processes between networks of stakeholders. This involves creating shared visions and goals, mobilizing change through transition experiments, and learning and evaluation of the relative success of these experiments (Kemp and Rotmans, 2005; Loorbach, 2007). Transition management is thus seen as a form of participatory policy-making based on complex systems thinking. A key element of this process is the creation of a 'transition arena', in which a relatively small group of innovation-oriented stakeholders comes together to engage in a process of social learning about future possibilities and opportunities.

***Socio-technical scenarios***

The multi-level perspective has also been used as the basis for developing *socio-technical scenarios*, which seek to explore the potential future development of socio-technical systems through interactions between ongoing processes at the three levels (Elzen et al., 2002; Hofman et al., 2004; Sondeijker et al., 2006). These are claimed to be an improvement on conventional foresighting or scenario methods, as follows (Elzen et al., 2002):

- Incorporation of qualitative elements, such as actor strategies, social networks and learning processes, as well as quantitative elements, such as price and performance of technologies;
- Focus on potential for radical technological change;
- Taking a systems approach, which examines complementaries as well as competition between technologies, in relation to changes in user preferences, policies and cultural values;
- Analysis of meso (regime) and micro (niche) level dynamics, involving the interactions between actors within a sector, as well as ongoing dynamics at the macro (landscape) level.

Our theoretical approach to developing transition pathways is an elaboration of the socio-technical scenarios method, augmented by recent thinking in innovation systems and co-evolutionary research. The theoretical basis for linking these different methodologies, which builds on the work of Markard and Truffer (2008), is described briefly in the next section, and in more detail elsewhere (Foxon et al., 2009).

## 3. Methodology for developing transition pathways

We are following an iterative process, both in developing our transition pathways and in building multi- and interdisciplinary working within the consortium. An initial set of outline pathways is being developed. These will then be investigated and compared using a range of modelling and assessment tools and criteria, both to assess their plausibility and to identify areas where more detailed specification is needed. This will include identification of endogenous decisions that are amenable to influence by UK actors, and those that are not, including key landscape changes or perturbations, for which exogenous assumptions will be made.

There are three main steps in our approach to identifying the initial outline transition pathways:

(1) *Characterise the existing energy regime, its internal tensions and landscape pressures on it*;

(2) *Identify dynamic processes at the niche level*; and

(3) *Specify interactions giving rise to or strongly influencing transition pathways*.

These three steps are applied in an iterative loop to specify these characteristics, processes and interactions at progressively greater detail, as follows.

(1) *Characterise the existing energy regime, its internal tensions and landscape pressures on it*

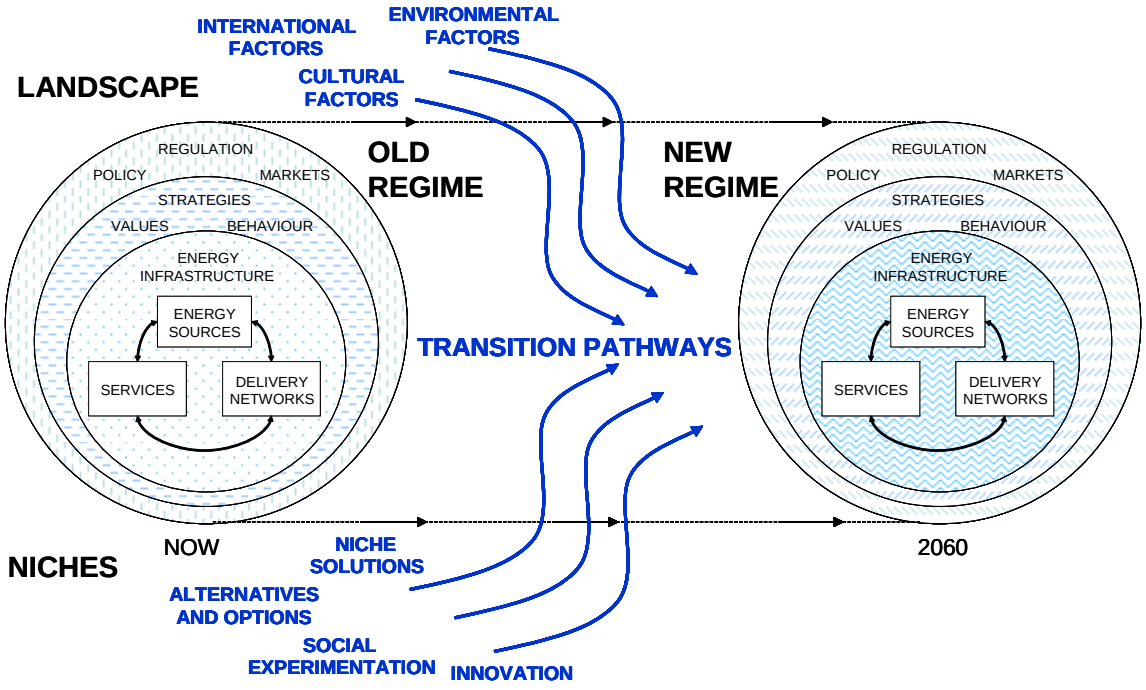


*Figure 1: Possible Transition Pathways and the Factors that Influence them (Source: Transition pathways project team)*

To establish potential future transition pathways in UK energy systems, we first need to characterize key elements of the existing regime, as well as identify key processes influencing the dynamics of change and stability (summarized in Figure 1, where the different shadings represent different configurations at the start and end of the transition). We begin by characterizing the *socio-technical regime* that meets energy service demands by households, businesses and organizations. These services include lighting, heating, cooling and the use of electrically powered appliances. (The regime for meeting mobility/transport services is currently largely separate, though in some future pathways, these regimes may become more intertwined, e.g. via plug-in and/or hybrid electric vehicles.) These demands are met through delivery networks which transfer power and energy from energy sources embedded in energy infrastructures. Three main physical infrastructures underpin UK energy service delivery, namely the national electricity and gas transmission and distribution networks and the buildings infrastructure, a key determinant of the levels of service demand.

A diverse range of actors and networks lie within the electricity regime. Following Verbong and Geels (2007), we focus on households, large industrial users, energy supply companies, distribution network operators, transmission system operators, electricity generators, national government, and regulators. These actors' behaviours may be characterized by the values they hold, the resources they command, and the strategies they choose to follow. These are in turn influenced by the institutional factors of national policies, market rules, and regulatory structures.

Following the multi-level perspective, the regime is also influenced by wider landscape factors and niche alternatives (Rip and Kemp, 1998; Geels, 2002, 2005a). *Landscape factors* include public awareness of climate change and willingness to accept and undertake changes in response, government commitments to meet national and international targets for emissions reductions and promotion of low carbon energy sources, ideological commitments to liberalized energy markets, concerns over security of primary energy supplies, external factors leading to high oil and gas prices – and concerns about energy affordability and fuel poverty, and factors which threaten physical disruption of external supplies (war, terrorism, foreign governments limiting supply, etc.), as well as changes in the international economic and financial situation. *Niche alternatives* include the demonstration of new technological options, new ways of organizing systems for meeting energy service demands and new ways of adapting energy-using behaviour (Kemp and Rotmans, 2005).

(2) *Identify dynamic processes at the niche level*

The next step in our approach is to characterize how processes at the niche level can potentially destabilize the existing regime and contribute to the formation of a new regime over the medium and long-term.

The idea that new technologies and practices arise in niches, which are partially protected from the selection pressures of the existing regime, was a key insight for the development of the transitions approach and its policy application. Niches here represent either segments of markets with particular demand features and/or proto-markets intentionally created by policy regulations or incentives to encourage the development of alternatives. The latter is referred to as strategic niche management (Kemp et al., 1998).

Though initially defined in terms of markets, niches also comprise technologies, institutions, business strategies and user practices, and we are interested in the processes through which change in these can occur. The transition literature says relatively little about the processes through which niches grow and challenge existing regimes. However, these processes have been the subject of much attention in the innovation systems literature. There has been relatively little interaction between these two literatures, but our approach to relating them is similar to that of Markard and Truffer (2008). An innovation system may be broadly defined as "the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge" (Lundvall, 1992). Here, we focus on technological innovation systems, defined as the actors, networks and institutions involved in the generation, diffusion and utilization of new technologies and new ways of organizing the provision of end-use services (Jacobbson and Bergek, 2004). In terms of the multi-level perspective, innovation systems provide the social and institutional context for the development of new technologies and new organizational alternatives at the niche level. A technological innovation system may encompass one or more technological/ market niches, as shown in Figure 2.

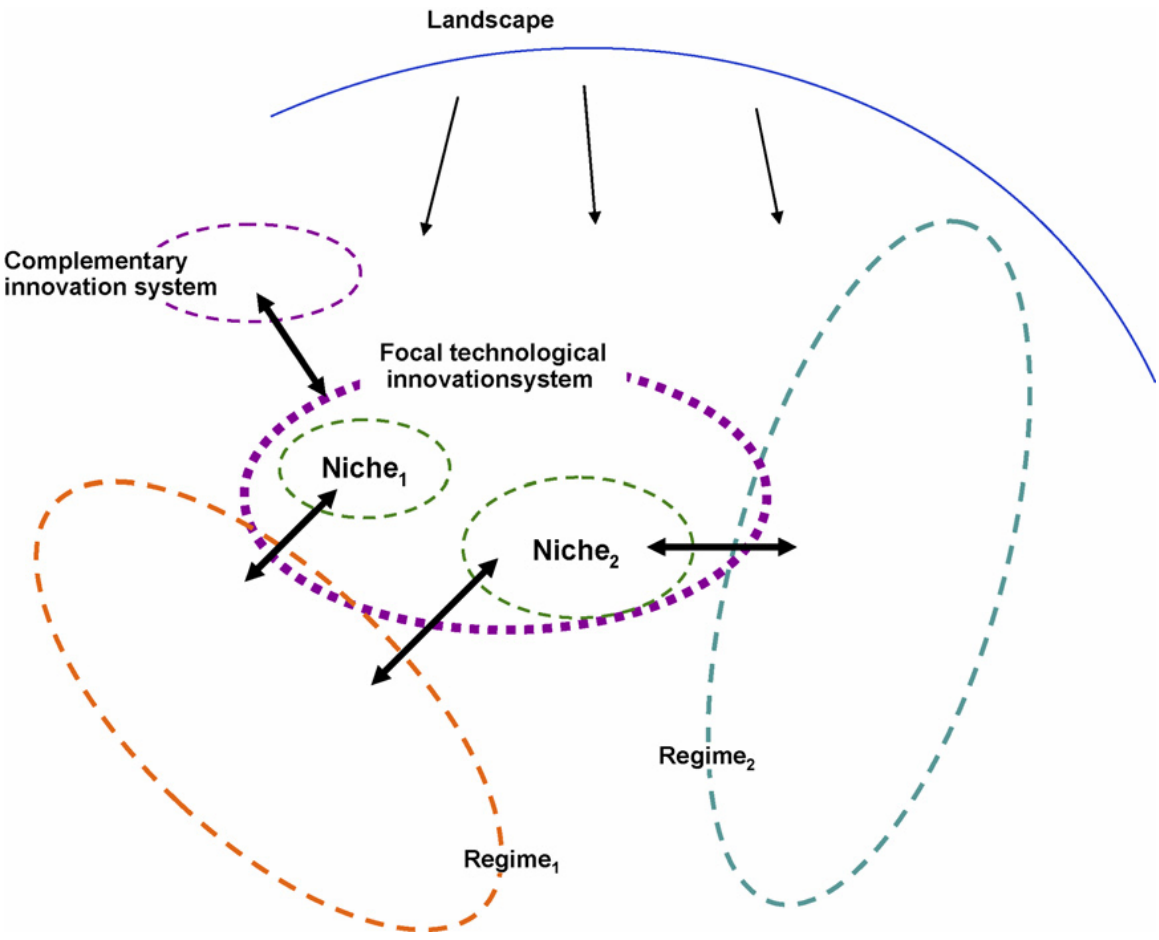


*Figure 2. Combining Technological Innovation Systems and the Multi-level Perspective (Source: Markard and Truffer, 2008)*

(3) *Specify interactions giving rise to or strongly influencing transition pathways*

Following the multi-level perspective, transition pathways are defined by the interactions between the internal regime dynamics and wider landscape factors and niche alternatives, which destabilize the incumbent regime and eventually give rise to a new regime. We examine pathways based on alternative plausible governance patterns for UK energy systems and how these patterns could affect technological, institutional and social changes in these systems. 'Governance' refers to how the interactions between choices made by different actors within the system, including national and local policy-makers, large firms and new entrants, financial investors and end-users, give rise to changes to the system (Smith, 2009). This approach enables us to explore how social and political issues, such as public acceptability of different technologies and institutional changes, the mixture of short-term and long-term drivers and influences affecting policy-making, and the strategies of large and small firms, interact or 'co-evolve' with present and expected future changes in technologies. The actors within the system have a range of individual and social goals, including the pursuit of personal and corporate advantage, the supply and provision of energy services at reasonable costs, maintaining security of supply, and contributing to wider social and environmental aims, which may often conflict in practice. Particular institutional arrangements strongly influence the governance of energy systems and consequently frame the ways in which these conflicts are resolved. In turn, the institutional arrangements and governance processes shape the patterns of technological change that arise.

## 4. Exploring transition pathways with different governance patterns

As noted, our outline transition pathways focus on alternative plausible governance patterns for UK energy systems and how they could affect technological, institutional and social changes in these systems. The governance patterns relate to the mix and balance of actions led by central government, actors in liberalized markets and civil society actors. We have designed an interpretive frame to assist in this analysis of these different governance patterns, as shown in Figure 3.

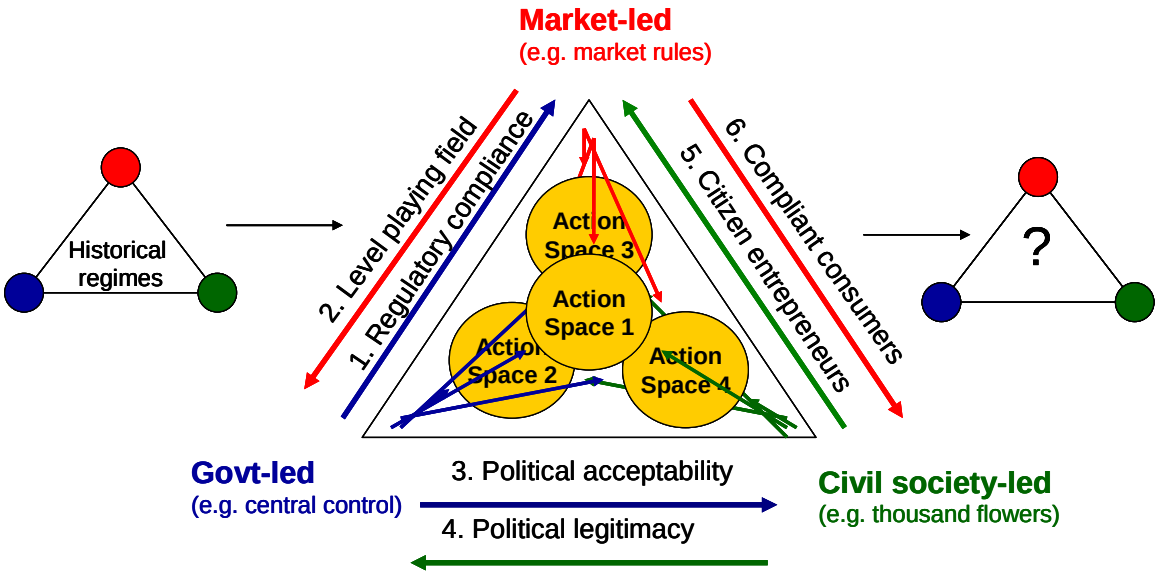


*Figure 3. Action space for transition pathways (Source: Authors)*

In this frame, the main actors are very broadly categorised into three different types:

1. Government-led – this covers government departments, advisory and regulatory bodies, and the legislation they create.
2. Market-led – this covers the major vertically integrated supply companies, but also smaller market based actors e.g. emerging energy service companies (ESCOs).
3. Civil Society-led – this includes not only 'end-users', but also other civil society actors such as trade unions, the media, and organised environmental protest movements.

These three different kinds of actors create a broadly defined 'action space' in which the current energy regime sits. Depending on which of these kinds of actors is deemed to have most 'power', different kinds of relationships between actors exist and different forms of transition may develop. Reflecting on these relationships through this interpretive lens could provide insights on how the initial phases of transition pathways may play out within the current energy regime, and how different actors are likely to react to transition processes. This will then inform the further development of the pathways.

In particular, we can see at least six different kinds of relationships that might hold between these three broad categories of actors, each one depending on which category of actor is deemed to have most 'power'. These relationships may be understood as 'ideal types', which can inform the analysis of more complex types of power dynamics in reality. If government actors are deemed most powerful, then we suggest a relationship of 'regulatory compliance' is most pertinent between such government actors and other market actors. In these circumstances, market actors are expected simply to comply with government targets – posing interesting questions about how these targets are set and how achievable they may be. If, on the other hand, market actors are deemed most powerful, then industry representatives are likely to call for a well defined carbon price and a 'level playing field' between different kinds of technologies and actors. If market actors held most power, therefore, we can suggest that this would be the dominant relationship between these two categories of actor.

Considering relationships between government and civil society actors produces two different forms of relationship. If government has most power within the energy regime, we can see a relationship of 'political acceptability' emerging, wherein the primary concern is to ensure that projects get through the planning regime and that civil society actors are sufficiently educated and 'onside' to enable policies to succeed. If civil society actors held more power, however, we could see questions of 'political legitimacy' being posed – for example, if a government tried to impose an unpopular policy on civil society groups, questions may be asked as to the legitimacy of such decisions – protests and other forms of civil disobedience may follow here.

Reflecting on relationships between market and civil society actors, if civil society actors had most power, we can see a new breed of 'citizen entrepreneurs' emerging. In this instance, citizens become much more active in the energy regime generating and exporting their own electricity perhaps, but also engaging politically to ensure key planning decisions go the way they wish. Finally, if market actors ruled the regime, we can see a dominant relationship with 'compliant consumers' – this is one in which the market is seen to 'know best' and consumers simply comply with the price signals it sends.

This representation thus provides an interpretive framework through which to understand and conceptualise the existing energy regime. Using it, we can tease out the various relationships that currently exist, and the various struggles to define the rules and lead the 'action space' that occur. Accordingly, it provides a powerful means by which to consider how the energy regime changes over time and how it may change in transition processes.

## 5. Outline transition pathways

Using this framework, we are developing and exploring a set of transition pathways to a low carbon energy system for the UK. These pathways explore different governance patterns, depending on the relative power and influence of the different categories of actors, and the mix and balance of centralized and decentralized decision-making within energy systems. The specification of these pathways draws on the experience of the project team, and the insights provided by the stakeholders at a workshop and through the 'gatekeeper' interviews. Our initial outline pathways are as follows.

The first pathway, *Market Rules*, envisions the broad continuation of the current market-led governance pattern. Here, the government specifies the high level goals of the system and sets up the broad institutional structures, in an approach based on minimal possible interference in market arrangements. These are held to be the most effective and efficient mechanism for energy service delivery. As anticipated, this perpetuates the present centralized generation system in which energy services are supplied mainly by large, vertically integrated firms. The underlying philosophy also allows for overseas investment to count towards UK targets, through the use of Joint Implementation, the Clean Development Mechanism and other flexible mechanisms. Stresses will become evident in this pathway, however, including whether sufficient investment is made in appropriate skills and technological capabilities to enable UK domestic emission reduction targets to be met.

The second pathway, *Action/Reaction*, may be interpreted as a bifurcation of *Market Rules*. It envisions the continuation of the current governance pattern in the short term, but then a failure of the centralized system to deliver on energy security and climate change goals leads to renewed interest in decentralized systems, together with a greater focus on energy saving and the development of energy service companies. This could occur through stronger governmental intervention, driven by the need to deliver on agreed climate change targets and concerns over short-time maintenance of supplies, and by resources freed up by decline in investment in centralized options being focused on the scaling up of decentralized options which have previously flourished in niche markets.

The third pathway, *Central Control*, envisions greater direct governmental involvement in the governance of energy systems. This could involve the setting up of a government-owned or funded 'Strategic Energy Authority' and/or the use of central contracts for the delivery of new low carbon generation, including nuclear power, offshore wind and coal with CCS. The initial focus would be on overcoming perceived blockages in the current system, by addressing transmission constraints, planning issues, supply chains and skills, and introducing non-behavioural measures on the demand side, including increasing energy efficiency standards on products and new build housing. By leading on these measures and providing strong 'technology push' on offshore technologies and CCS for UK industrial as well as climate benefits, these actions would then legitimate further governmental steps to influence lifestyles and behaviours.

The fourth pathway, *Thousand Flowers*, envisions a sharper focus on more local, bottom-up diverse solutions ('let a thousand flowers bloom'). These developments are driven by innovative local authorities and citizens groups, such as the Transition Towns movement (Hopkins, 2008), to develop local micro-grids and energy service companies. A variety of more locally based technological and institutional solutions then begin to spring up, challenging the dominance of the existing large energy companies.

The project team is currently undertaking a second iteration of the specification of these pathways. In this second iterative loop, we are undertaking an initial 'ball-park' quantification of the existing regime dynamics and the dynamic processes at niche levels, for each of the initial outline transition pathways. This will lead to a fuller specification of these outline pathways.

## 6. Analysing and exploring the pathways

We conclude by briefly describing the next steps to be taken by the project team in examining the outline transition pathways, under three project Themes. Theme 1 (*Transitions, scenarios and historical analysis*) will complement the above analysis with insights for transition pathways from existing scenarios for development of UK energy systems to 2050, and from historical analysis of long-term developments in use and costs of energy services arising from technological and social changes. Theme 2 (*Technical and social analysis of supply-side, demand-side and infrastructure networks*) includes testing for technical feasibility using electricity network models, and explorations of social acceptability using participatory and deliberative methods. The latter will involve the use of semi-structured interviews with relevant actors, including households and SMEs, to inform how demands for alternative technological, organizational and behavioural options might be generated. Theme 3 (*Systems Appraisal and Joint Working, Integration and Learning*) will provide a whole-systems assessment of the pathways within a sustainability (technical, environmental, economic and social) framework. This will be used to identify key constraints and 'tipping points' which might limit or enhance the potential transition pathways. Further interactions with public and private stakeholders in future stakeholder workshops will help test and refine the developed transition pathways and related whole-systems assessments. The 'final' pathways and assessments, and the participative processes used in their development, should contribute to ongoing UK and international energy policy debates about the actions and institutional changes needed for a transition to a low carbon energy system.

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