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Transition pathways for a UK low carbon electricity future

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ABSTRACT

Achieving long-term targets for greenhouse gas emissions reductions, such as the UK's legally-binding target of reducing its emissions by 80% by 2050, will require a transition in systems for meeting and shaping energy service demands, involving radical substitution to low-carbon supply technologies and improvements in end-use energy efficiency. This paper describes the development and high-level analysis of a set of transition pathways to a UK low carbon electricity system, explaining key features of the core pathways developed and the distinctiveness and value of the approach. The pathways use an 'action space' concept to explore the dynamic interactions between choices made by actors, which are influenced by the competing governance 'framings' or 'logics' that different actors pursue. The paper sets out three core transition pathways – *Market Rules*, *Central Co-ordination* and *Thousand Flowers*, in which market, government and civil society logics respectively dominate. It summarises the key technological and institutional changes in these pathways, and the roles of actors in bringing these about. This leads to an identification of the key risks to the realisation of each of the pathways, and of the challenges for individuals, businesses, social movements and policy-makers in taking action to bring them about and sustain them.

1. Introduction

In 2008, the UK Parliament passed the Climate Change Act, which set a legally-binding goal to reduce the UK's greenhouse gas emissions by 80% below 1990 levels by 2050. It also established an institutional framework for setting intermediate carbon budgets and holding the UK Government to account for measures to achieve them. The Committee on Climate Change (CCC), consisting of experts in climate science, technology and economics, was set up to advise the Government and recommend the carbon budgets, starting with the first three budget periods 2008–12, 2013–17 and 2018–22. Based on technical and economic modelling and analysis, the Committee's scenarios for achieving these budgets focussed on the UK moving to a 'highly-electric' future, in which electricity, generated from low-carbon sources, is increasingly used as the main energy carrier for heating and transport, as well as for other power and lighting services. Despite the fundamental transformation of the UK energy system that this implies, most UK scenario work (CCC, 2008; DECC, 2010a; Skea et al., 2011) has focussed on the rates of adoption of low-carbon technologies needed and the additional energy system costs involved, with relatively little discussion of the motivations of the different actors involved, the interactions between them and the choices and actions needed to 'get from here to there'.

This paper describes research developing scenarios or transition pathways to a UK low carbon electricity future by 2050 that focuses on the actions of the actors, both large and small, and the governance arrangements that frame the choices involved. This is part of a large research project, involving engineers, social scientists and policy analysts from nine UK universities, that is analysing the technical and economic feasibility and social and environmental potential and acceptability of these pathways, as reported in the companion papers in this special issue. The approach to developing transition pathways, described in detail elsewhere (Foxon et al., 2010), applies recent research using a multi-level perspective for analysing transitions in socio-technical systems, such as energy systems (Geels, 2002, 2005, 2011; Grin et al., 2010), and related work on a coevolutionary framework for analysing low-carbon transitions (Foxon, 2011). Transition pathways arise through the dynamic interaction of technological and social factors at and between different levels, mediated by the actions of actors within an 'action space'. Three key types of actor influence change: government actors; market actors, such as large energy firms; and civil society actors, such as community and environmental groups. We argue that these different actors have fundamentally different 'logics' or framings of the key energy challenges. Hence, the logic or framing that dominates a pathway will have a crucial influence on energy choices made and the shape of any future low-carbon energy

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system. We develop and analyse three core transition pathways, named *Market Rules*, *Central Co-ordination* and *Thousand Flowers*, in which the logic or framing of market actors, government actors, and civil society actors respectively dominate.

The pathways thus aim to inform thinking by policy-makers, energy firms and civil society actors by showing how different framings of the issues could lead to radically different low-carbon energy futures. This suggests the need for a much deeper debate on what kind of energy future we, as a society, would like to see. The relative priorities and potential trade-offs between carbon reduction and other objectives, including maintaining energy security, contributing to economic prosperity and ensuring affordability of energy services, are then inherently political. The paper aims to contribute to this debate by examining how different framings and choices could lead to different outcomes, and highlighting the challenges that this poses for different stakeholders.

Section 2 of the paper outlines the approach taken to developing transition pathways, in relation to the multi-level perspective and action space. Section 3 describes the methodology followed in applying this approach to UK electricity systems, and how the pathways inform and are informed by the other parts of the analysis in the research project. Section 4 sets the context for our transition pathways by analysing recent UK energy policy developments, identifying a move away from a purely market-oriented governance framework to one in which central government is beginning to play a more active role, though still with a limited role for civil society actors. Section 5 describes our core transition pathways for a UK low carbon electric future, highlighting the key technological and institutional changes in these pathways, and the roles of actors in bringing these about. Section 6 discusses the challenges for individuals, businesses, social movements and policy-makers in taking appropriate action to bring them about. Section 7 concludes by discussing the distinctive features of the transition pathways approach.

2. Approach to developing low-carbon transition pathways

In framing the challenge of moving to a sustainable low carbon energy system, whilst achieving other objectives of maintaining security of energy supply and affordability of energy services, governments have begun to use the language of transitions. In the foreword to the UK Government's July 2009 Low Carbon Transition Plan, Ed Miliband, the then Secretary of State for Energy and Climate Change (and now Leader of the opposition Labour Party), stated, "The transition to a low-carbon economy will be one of the defining issues of the 21st Century" (HM Government, 2009, foreword). Through such documents and associated policies, national governments seek to play a leadership role; nevertheless, as Miliband acknowledges, a low-carbon transition cannot be achieved without the active engagement of market and civil society actors, "… every business, every community will need to be involved" (HM Government, 2009, foreword). Such exhortations are often accompanied by an optimistic vision of a low carbon future – "Together we can create a more secure, more prosperous low carbon Britain and a world which is sustainable for future generations" (HM Government, 2009, foreword).

In practice, a transition to low carbon systems of energy supply and energy service provision will require radical changes to technologies, institutions, business strategies and user practices; hence, it raises governance challenges in relation both to the engagement of different actors and to the incentives and barriers they face (Foxon et al., 2010). 'Governance' here refers to the structures and processes that influence decisions made by different actors within the system, including national and local policy-makers, large firms and new entrants, financial investors and end-users, and how these choices give rise to changes to the system (Smith, 2009). Technological and economic modelling currently form the dominant modes of analysis of future low carbon energy systems. This arguably relates to the predominant influence of economic thinking on policy-making in this area, such as the requirement of identifying 'market failures' in order to justify government action. This then tends to militate against considerations of wider social impacts and benefits. We argue that there is a need for analytical frameworks that can address the interactions of social and technological factors, in order to address these wider governance challenges. Public debates about climate change policy often focus on the desirability of particular technological options, such as wind farms or nuclear power stations. However, we would suggest that these debates reflect deeper arguments about alternative visions of future societies. The research described in this paper examines alternative pathways to different low-carbon electricity system futures for the UK under different governance arrangements, in order to inform these deeper arguments. The work aims to examine how governance processes actively engage with and shape a low-carbon transition by analysing the tensions and choices faced by key actors, and how the actors may respond to these choices.

This work is being undertaken by an interdisciplinary consortium of UK researchers, involving engineers, social scientists and policy analysts, supported by the UK Engineering and Physical Sciences Research Council (EPSRC) and the integrated power and gas company E.On. It builds on the expanding literature on socio-technical transitions using a multi-level perspective (Geels, 2002, 2005; Grin et al., 2010; Smith et al., 2010; Geels, 2011). This combines technical, social and historical analysis of and insights into past and current transitions, using an analytical framework based on interactions between three levels: technological niches, socio-technical regimes, and landscapes. The *landscape* represents the broader political, social and cultural values and institutions of society; the *socio-technical regime* reflects the prevailing set of routines or practices that actors and institutions use and that create and reinforce a particular technological system; and *niches* represent spaces that are at least partially insulated from 'normal' market selection in the regime that provide places for technological and social learning to occur.

The motivation and theoretical basis that we apply for specifying transition pathways has been described in detail elsewhere (Foxon et al., 2010) and is depicted in Fig. 1. This draws on an analytical framework based on the multi-level perspective (MLP) and a related framework for analysing the co-evolution of ecosystems, technologies, institutions, business strategies and user practices for a transition to a low carbon economy (Foxon, 2011). This builds on, but goes beyond, existing approaches to analysing socio-technical transitions. As described in Foxon et al. (2010), these approaches have developed along three main lines: (1) using the MLP as a framework for the analysis of the historical dynamics of transitions; (2) analysing processes of governance for 'transition management'; (3) elaboration of socio-technical scenarios for future transitions. Our approach develops the latter work on socio-technical scenarios using the multi-level perspective, which "describes a potential transition not only in terms of developing technologies but also by exploring potential links between various options and by analysing how these developments affect and are affected by the strategies (including policies) and behaviour of various stakeholders" (Elzen et al., 2002; Elzen and Hofman, 2007; Hofman et al., 2004; Hofman and Elzen, 2010). As may be seen from the book by Grin et al. (2010), which sets out the state of the art in sustainability transitions research, most of this research has explored the first two of these lines, with