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Editorial

Past and prospective energy transitions: Insights from history

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ABSTRACT

This introduction to the special issue on past and prospective energy transitions presents some insights from research into past energy transitions of relevance for a possible transition to a low carbon economy. It also provides a synthesis of insights generated during a workshop attended by many of the leading researchers on this topic at Cardiff University in April 2011. The final section introduces the articles in the special issue. It is hoped that the workshop and this issue will help to move forwards the integration of the exciting research on past energy transitions in ways that will also offer valuable insights into the challenges of prospective low carbon transitions.

1. Introduction

Climate change is likely to be one of the greatest threats to global economic security and social stability in the course of the twenty-first century. The global economy's willingness and ability to reduce carbon dioxide emissions and control greenhouse gas concentrations will be crucial for climate stabilization. Many suggest that a transition to a low carbon economy would be an important step towards meeting this demand for climate stability (Grubb et al., 2008; Foxon et al., 2008).

Many aspects of future energy transitions are highly uncertain (by 'energy transition', we mean the switch from an economic system dependent on one or a series of energy sources and technologies to another). The building blocks necessary for understanding such transitions include theory, empirical evidence and analysis, and simulation exercises. Energy transitions, however, have in the past tended to be relatively rare events whose complex and long drawn-out processes unfolded over decades and sometimes centuries. This implies that to gather qualitative and quantitative data about and insights into energy transitions, researchers should not confine themselves only to evidence from the recent past. Furthermore, identifying patterns in energy transitions for a particular country (with some semblance of social and cultural continuity) rather than across countries may require the analysis of events over hundreds of years.

In addition to historical expertise, the analysis of energy transitions has benefitted from researches associated with a number of other disciplines ranging from economics and sociology to geography and engineering. The practitioners of these disciplines normally publish their research in separate journals, and those interested in their observations and insights must search through many different literatures. In our view, a richer and more integrated understanding of past and prospective energy transitions will flow from closer contacts and joint work across these disciplines.

In order to facilitate more integrated understanding and sharing of knowledge, a three-day workshop was organized at Cardiff University in April 2011 (see Acknowledgements below). At this workshop, a multi-disciplinary group of the leading researchers on past energy transitions came together to share their research, ideas and conclusions. There were 20 talks, including keynote speeches from Robert C. Allen and Arnulf Grübler, a series of break-out groups and many informal discussions.

Following the success of the workshop, many agreed that the 'ball needed to keep rolling', and that a special issue of Energy Policy would be a good way to do this. Thus, this special issue seeks to bring together some of the different literatures on past energy transitions and to raise awareness among those concerned with energy policy of the rich possibilities of learning from them.

In this introduction to the issue, we first present some insights from recent research into past energy transitions. This does not pretend to be a review of the literature, and aims to do no more than complement the reviews provided by the articles in the special issue. The third section attempts a synthesis of some of the comments made during the Cardiff workshop. The final section introduces the articles in the special issue. We hope that this special issue will help to move towards a closer integration of the exciting on-going research on past energy transitions, while also offering valuable insights into the challenges of and policies for prospective low carbon transitions.

2. Some insights from research into past energy transitions

As mentioned, researchers concerned with energy policy from a range of disciplines have looked into the past to investigate

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transitions that took place in current industrialised economies. Schurr and Netschert (1960), for example, presented one of the first case studies of a transition from biomass to coal to petroleum in the US. This broad transition was much faster in the US (i.e., decades instead of centuries) than for the United Kingdom (Humphrey and Stanislaw, 1979; Fouquet and Pearson, 1998; Warde, 2007; Fouquet, 2008). Other European experiences showed that the broad historical context (including resource availability, industrial and household energy demands institutions and government policies) was important for explaining specific energy transitions (Gales et al., 2007; Bartoletto and Rubio, 2008; Madureira, 2008; Kunnas and Myllyntaus, 2009).

Historical evidence has offered a number of insights into how prospective energy transitions might unfold. A review of 14 past transitions indicated that, for a new energy source to become dominant, the energy services (such as space and water heating, powering machinery and appliances, passenger and freight transport, and lighting) it provided had been cheaper than the incumbent energy source (Fouquet, 2010). That is, generally, where the energy transition succeeded, the cost of producing the service (e.g., the effective heating generated, the passenger-kilometres travelled, or the lumen-hours generated from lighting), as estimated by combining the energy price and the energy efficiency of the conversion technology for the new source, was lower than for the incumbent source. While this study did indicate that many of the services provided by the new source were initially more expensive than those from the incumbent source, the new energy source or its related technology offered enhanced characteristics (including ease of use, flexibility and cleanness, or exclusivity, novelty and status) that consumers were willing to pay for. This suggests that the new energy sources and technologies initially developed in niche markets and that when the services associated with them became sufficiently cheap to compete with the incumbents and diffused more widely, an energy transition was likely to unfold. Indeed, in this stage of a potential transition, both learning and major economies of scale were vital for the new energy source and technology to compete (Grübler et al., 1999).

In the transitions explored, the process from technological innovation to niche market to dominance took a minimum of 40 years. An aggregate energy transition, involving the entire economy, could take centuries, as it depended on the switch in fuels and technologies for multiple energy services in many sectors (Fouquet, 2010; Allen, 2009; Mokyr, 2009). Although requiring further research, it appears that in many cases the process of the transition was not smooth. Transitions have often depended on the timing and influence of broader external landscape forces. Both the price of the energy service and the price of the energy matter. For instance, peak energy prices, as occurred for coal in 1921 and 1926, or for oil in 1973, 1979 or 2008, sometimes pushed consumers away from a particular energy source, while scrapping old technology associated with the incumbent source. Then, in the next period of economic growth, some producers and consumers were willing to make investments in new technologies and networks. So, although energy service prices have been crucial for determining consumer choices, fluctuations in energy prices have been critical for diverting consumers away from one energy source and technology and towards another, and in combination with the relative prices of labour and capital, have been instrumental in giving producers incentives to develop new technologies (Allen, 2009).

The nature of a new energy technology (as well as the companies or oganisations selling and promoting it) has played a crucial role in its uptake (Smil, 1994, 2010). However, successful uptake tended to depend on the co-evolution of technologies, industries and institutions that enabled new energy sources to emerge from niches and become core elements in the regime (Geels, 2002; Foxon, 2011). This allowed 'technological clusters' to dominate and ultimately create 'lock-ins' (Grübler et al., 1999; Unruh, 2000; 2002; Unruh and Carrillo-Hermosilla, 2006). At the same time, the losing incumbents (in any transition) have been known to 'fight back', potentially creating 'sailing ship' or 'last-gasp' effects (Rosenberg, 1976; Utterback, 1994; Snow, 2010). Also, in certain countries, resource endowments and government objectives were pivotal in pushing or delaying the uptake (e.g., Madureira, 2008).

Historical experience also suggests that energy transitions have been characterised by major increases in energy consumption (Grübler, 2004). Looking at trends in global energy consumption since 1800, Fig. 1 shows that each energy transition has led to greater energy consumption. Inevitably, the share of individual energy sources changed (from woodfuel to coal to petroleum and increasingly towards natural gas), yet the absolute consumption of each energy source has continued to increase, albeit more slowly than for the new sources. Thus, even a major shift towards low carbon energy does not guarantee that the global economy will reduce fossil fuel consumption. Instead, such a shift may simply promote overall greater energy consumption.

Energy transitions which led to major reductions in the price of energy services (Fouquet, 2011) and increases in the consumption of energy services (Fouquet and Pearson, 2012), have often been associated with periods of rapid economic growth and of major transformations in economic structure and activity (Cipolla, 1962; Wrigley, 1988, 2010; Allen, 2009; Ayres and Warr, 2009; Mokyr, 2009). Many of the historical energy transitions do fit within a broader cluster of technologies and were supported by a set of institutions—each cluster and set representing a distinct era or 'wave' of economic growth (Freeman and Louça, 2001). Thus, one might expect that a transition to a low carbon economy could also be the source for the transformation of the economy and of a new phase of major economic growth.

Historically, carbon dioxide emissions from fossil fuels were not always the main source of greenhouse gas emissions (see Fig. 2). Prior to the transition to and growth in fossil fuel consumption, anthropogenic greenhouse gas emissions (from methane and land-use related carbon dioxide) appear to have been relatively stable. So, this invites us to believe in the stabilization of greenhouse gas emissions to the levels that existed before 1850 and the global transition to fossil fuels.

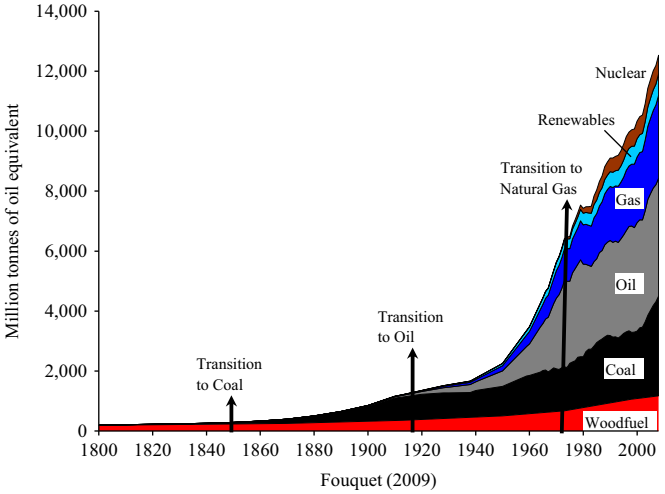

Fig. 1. Global energy consumption and transitions, 1800–2010. *Source*: Fouquet (2009).