



Synergies and trade-offs between governance and costs in electricity system transition



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HIGHLIGHTS

- Cost appraisal of the UK electricity system under alternate governance logics.
- Novel linking of qualitative governance narratives with quantitative cost appraisal.
- A Market pathway requires the lowest investment costs until 2050.
- A Government pathway can have the lowest total costs, if policies can be enacted.
- A Society pathway is the most costly, but ensures wider participation of the society.

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ABSTRACT

Affordability and costs of an energy transition are often viewed as the most influential drivers. Conversely, multi-level transitions theory argues that governance and the choices of key actors, such as energy companies, government and civil society, drive the transition, not only on the basis of costs. This paper combines the two approaches and presents a cost appraisal of the UK transition to a low-carbon electricity system under alternate governance logics. A novel approach is used that links qualitative governance narratives with quantitative transition pathways (electricity system scenarios) and their appraisal. The results contrast the dominant market-led transition pathway (*Market Rules*) with alternate pathways that have either stronger governmental control elements (*Central Co-ordination*), or bottom-up proactive engagement of civil society (*Thousand Flowers*). *Market Rules* has the lowest investment costs by 2050. *Central Co-ordination* is more likely to deliver the energy policy goals and possibly even a synergistic reduction in the total system costs, if policies can be enacted and maintained. *Thousand Flowers*, which envisions wider participation of the society, comes at the expense of higher investment and total system costs. The paper closes with a discussion of the policy implications from cost drivers and the roles of market, government and society.

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1. Introduction

In 2008, the United Kingdom (UK) was the first G20 economy to adopt an ambitious, legally-binding target to reduce its greenhouse gas emissions from the energy sector by 80% in 2050, as compared to the levels of 1990. Multiple studies showed that this target could be achieved at least cost through an early transition to low-carbon electricity generation, which would then facilitate the electrification of heating and transport (Anandarajah et al., 2009;

Ekins et al., 2011; Williams et al., 2012). The UK Department of Energy and Climate Change (2012) estimates that £110 billion of investment (US\$170 billion) by 2020 is needed in the UK electricity generation, transmission and distribution system. Existing concerns about the costs and affordability of such a transition have been amplified by the global financial crisis in 2007–2008. Such concerns play a significant role in UK's recent Electricity Market Reform (DECC, 2012). In particular, the levels of investment needed (and who will pay for them) are highly debated (DECC, 2014a; Ernst & Young, 2009; LSE, 2012; National Grid, 2013b; Ofgem, 2009, 2010). In this context, this paper appraises the investment and total system costs of the UK transition to a low-carbon electricity system from 2010 to 2050.

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In a parallel track to this cost-focused debate, a multi-level perspective to socio-technical transitions has been developed. It focuses on governance and the choices of key system actors, such as electricity companies, government and civil society (Geels, 2002; Geels and Schot, 2007). The links between cost drivers and governance have been conceptually discussed. As compared to the state-governed electricity system, market rationale can improve the economic efficiency of the system and thus reduce the total system costs (Goldthau, 2012; Helm, 2003). Lately, market rationale has been challenged because it may not deliver high investment levels required for climate change mitigation and supply security (Bolton and Foxon, 2015; Goldthau, 2012). Even if the government could incentivize higher investment levels, this could increase the total system costs and feed back to affordability concerns. Such dynamic changes in governance have been retrospectively shown to substantially influence the energy system transition (Arapostathis et al., 2013; Pearson and Watson, 2011), but they have been barely analysed on quantitative basis. Existing studies on electricity system costs account for parametric uncertainties, such as economic growth and emission mitigation efforts (Ernst & Young, 2009; LSE, 2012; National Grid, 2013b; Ofgem, 2009, 2010), deployment levels of specific technologies (Ernst & Young, 2009; Hara, 2014), and supply security requirements (Ernst & Young, 2009). However, limited efforts were dedicated to quantitative, modelling-based analysis of the role of governance. This paper primarily focuses on the implications of alternative governance pathways on the UK's electricity system transition and its costs.

Quantitative modelling and cost appraisal of the electricity system transition under different governance pathways is a challenging task because our knowledge of governance is often of a conceptual and experiential nature (Hughes and Strachan, 2010; Pfenninger et al., 2014; Trutnevyte et al., 2014). For this reason, a story-and-simulation approach is appropriate (Alcamo, 2008; Schweizer and Kriegler, 2012; Swart et al., 2004; Trutnevyte et al., 2014; Trutnevyte et al., 2012). Qualitative governance narratives are linked with quantitative electricity system transition pathways (scenarios), and a cost appraisal is subsequently performed. Qualitative narratives allow for capturing the governance arrangements, decisions of the key actors and broader contextual developments that are often ignored in purely quantitative studies (Trutnevyte et al., 2014). Quantitative modelling and assessment allows for rigorous and internally consistent quantification of these narratives and their implications.

The cost appraisal, presented in this paper, is part of the Realising Transition Pathways project, funded by the UK Engineering and Physical Sciences Research Council. In this project, an interdisciplinary research team from nine UK universities investigates what needs to be done to achieve the UK electricity system transition that successfully addresses the energy policy 'trilemma', i.e. simultaneous delivery of low-carbon, secure and affordable energy services. In the preceding Transition Pathways project three narratives of this UK transition under alternate governance logics were developed: *Market Rules*, *Central Co-ordination* and *Thousand Flowers* (Foxon, 2013; Foxon et al., 2010; Hammond and Pearson, 2013). The *Market Rules* narrative represents the market-dominated governance, where the choices of electricity companies that interact with the national policy framework shape the electricity system transition. The *Central Co-ordination* narrative assumes the dominant role of the national government in delivering the low-carbon system. The *Thousand Flowers* narrative envisions civil society becoming the leading change agent through the deployment of bottom-up solutions.

These three governance narratives have already been addressed from the perspectives of technical feasibility (Barnacle et al., 2013; Pudjianto et al., 2013), environmental impacts

(Hammond et al., 2013; Hammond and O'Grady, 2013), supply security (Boston, 2013), and uncertainty and future branching points (Foxon et al., 2013; Hughes et al., 2013). In the project to date, the economic perspective has not been systematically considered using quantitative modelling approach and has only been discussed conceptually (Foxon, 2013; Hammond and Pearson, 2013). Thus, this paper adds this missing economic perspective to the Realising Transition Pathways project. In comparison to the other project's activities, this is the most comprehensive cost appraisal with the widest system boundaries (electricity generation, transmission and distribution, electric heating and transport, and cost savings due to replaced fossil fuel based heating and transport). Trutnevyte et al. (2014) present further efforts to combine eight technical feasibility, economic and environmental models to assess the *Central Co-ordination* narrative from a quantitative perspective beyond economics. Trutnevyte (2014) experiments with modelling of different electricity generation portfolios for the three governance narratives. But neither of the two latter studies appraises the costs of the narratives in such a detailed and broad manner.

The paper is structured as follows: Section 2 describes the methodology and introduces the Realising Transition Pathways narratives; Section 3 summarises and discusses the cost appraisal results; Section 4 interprets the results in terms of the previous studies, discusses the limitations and identifies future research needs; and Section 5 concludes with policy insights from the contrast between cost appraisal versus governance approaches to analysing long-term electricity transitions.

2. Methodology and the three governance narratives

The analysis starts with the qualitative governance narratives that describe governance arrangements, choices of the key actors and the respective energy transitions (Section 2.1). Each qualitative narrative is then 'translated' into a quantitative electricity system transition pathway (Section 2.2). This pathway shows the detailed, technically-elaborated evolution of the electricity demand and supply, including the technology choices of electricity companies and consumers. The costs of the quantitative pathways—that are the representations of the qualitative governance narratives—are finally appraised and compared (Section 2.3).

2.1. Governance narratives

The three governance narratives, described in detail by the Transition Pathways (2012) and by Foxon (2013), define alternate UK transitions to a low-carbon electricity system, its governance arrangements and the choices of key system actors from 2010 to 2050. The narratives distinguish between three ideal-types of governance logics (Fig. 1): market logic in the *Market Rules* narrative, government logic in the *Central Co-ordination* narrative, and the civil society logic in the *Thousand Flowers* narrative. While these narratives picture the ideal-type governance logics, the UK electricity system governance in reality will likely be a hybrid of all these three logics with different strengths. Today's governance is argued to be a hybrid of the *Market Rules* and *Central Co-ordination* narratives (Bolton and Foxon, 2013; Goldthau, 2012).

2.1.1. Market Rules narrative

The *Market Rules* narrative envisions that market logic will dominate the UK electricity system transition. Large electricity companies and other market actors will deliver the transition, when freely interacting with the policy framework. This policy framework will set broad goals and implementation mechanisms, but otherwise will minimise its interference. In this narrative, a

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