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Reconciling qualitative storylines and quantitative descriptions: An iterative approach

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ABSTRACT

Energy system transition research has been experimenting with the integration of qualitative and quantitative analysis due to the increased articulation it provides. Current approaches tend to be heavily biased by qualitative or quantitative methodologies, and more often are aimed toward a single academic discipline. This paper proposes an interdisciplinary methodology for the elaboration of energy system socio-technical scenarios, applied here to the low carbon transition of the UK. An iterative approach was used to produce quantitative descriptions of the UK's energy transition out to 2050, building on qualitative storylines or narratives that had been developed through the formal application of a transition pathways approach. The combination of the qualitative and quantitative analysis in this way subsequently formed the cornerstone of wider interdisciplinary research, helping to harmonise assumptions, and facilitating 'whole systems' thinking. The methodology pulls on niche expertise of contributors to map and investigate the governance and technological landscape of a system change. Initial inconsistencies were found between energy supply and demand and addressed, the treatment of gas generation, capacity factors, total installed generating capacity and installation rates of renewables employed. Knowledge gaps relating to the operation of combined heat and power, sources of waste heat and future fuel sources were also investigated. Adopting the methodological approach to integrate qualitative and quantitative analysis resulted in a far more comprehensive elaboration than previously, providing a stronger basis for wider research, and for deducing more robust insights for decision-making. It is asserted that this formal process helps build robust future scenarios not only for socio political *storylines* but also for the quantification of any qualitative storyline.

1. Introduction

In recent years, the energy sector has undergone strong and prolonged change which is set to continue (IEA, 2015), giving rise to high levels of uncertainty moving forward (Hughes et al., 2013). In this setting, scenarios and storylines offer a means by which these uncertainties can be captured by exploring possible (although not necessarily equally likely) futures. Storyline approaches of this type have therefore become widely used in the energy arena as a method of adding context and solving problems (Hughes and Strachan, 2010). Examples of scenario development and analysis can be found in the UK in academia (Jardine and Ault, 2008; Burt et al., 2008; Kannan and Strachan, 2009; Ault et al., 2008; Eames and McDowall, 2006), government (DECC, 2010) and from system operators (NationalGrid, 2011) alongside international examples from Denmark (Lund et al., 2010) and Japan (Ashina et al., 2012), together with global examples (Calvin et al., 2009; Gurney et al., 2009). The development of future energy system scenarios is highly prevalent and has become common practice in many fields in order to demonstrate system change through modeling and analysis (Hughes and Strachan, 2010).

In the UK the DECC 2050 pathways were designed by the Department of Energy and Climate Change (DECC) to try and answer questions with regard to demand, electricity production, fuel sourcing, technology choices and decarbonisation of the energy supply out to the year 2050 (DECC, 2010). The analysis, that accompanied the release of the DECC 2050 calculator (DECC, 2010, 2011), presented six *illustrative* pathways to demonstrate the variety and wide range of possible futures that could be explored, with no preference stated or panacea promoted. These pathways, draw on previous work (Elders et al., 2006, 2008), which

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examined six future electricity network scenarios for Great Britain in 2050, concluding that the main influences of scenario development will be from highly uncertain economic, political and technological factors.

Scenarios may be classified in many ways and one prevalent divide is between quantitative scenarios and qualitative storylines (Fortes et al., 2015). Both approaches bring their respective advantages when carrying out future-oriented research. Qualitative storylines provide a wider view of a transition, capturing features such as governance and behavioural change. Quantitative scenarios provide technical depth, describing the transition with empirical real-world data. However, qualitative storylines lack technical robustness and can often be fraught with bias from its development. Quantitative models too can be developed from a biased perspective and with a more narrow focus can only represent specific elements of a system under transition. In order to reduce bias, from either perspective or technique employed, research groups are starting to combine approaches, and experimenting with their integration to benefit from the richness that this supplies. A critical survey of energy scenarios to 2050 saw "little evidence of such combined approaches" (Söderholm et al., 2011) in the literature but did argue there are "strong arguments for paying increased attention to governance and legitimacy issues in the identification of policy-relevant scenarios for quantitative modelling".

Such a combined approach was developed by the Realising Transition Pathways (RTP) consortium when assessing the UK's transition to a low carbon economy (Realising Transition Pathways, 2016). This interdisciplinary research grouping comprised nine UK academic institutional partners, bringing together power systems engineers, environmental scientists, social scientists, energy economists and socio-technical transition scholars. The research within the RTP consortium centres on the analysis and examination of three transition pathway storylines developed by the first phase of the project, the 'Transition Pathways to a low carbon economy' (TP) consortium. These transition pathway storylines describe plausible evolutions of the UK towards a low carbon economy to 2050 (Foxon et al., 2010).

The three RTP pathways are differentiated by their dominant governance logics. The first entitled 'Market Rules' is based on a 'business as usual' approach in which there is a continuation of the UK's current governance pattern with minimal interference in the market. Large vertically integrated firms continue to supply the majority of the energy to the UK's passive consumers through the use of large-scale centralized plant and high level goals for the system, specified by the government, are delivered through institutional oversights and investment mechanisms. In contrast, Early and firm action is taken by the government in pathway 'Central Co-ordination' with the government stepping in to create a Strategic Energy Authority to ensure that emission reduction targets are met by encouraging the development of new supply side technologies, and pushing for delivery of such technologies. This leads to a mixture of large scale wind, nuclear and carbon capture and storage (CCS) coal and gas plants to supply a demand which has changed as the government acts to encourage increased efficiencies of products and housing influencing user behaviours. In the pathway 'Thousand Flowers' however there is a local, bottom-up, drive from individuals, community groups and local authorities engaging with, and actively participating in, the energy system. This allows for a diversity of local solutions to fulfil demand challenging the current dominance of large scale energy companies and sees 50% of demand being fulfilled by distributed generation.

Transition pathways (classed as socio-technical *storylines*), as described in (Foxon et al., 2008) and (Foxon et al., 2009), are derived from an engineering and social examination of the key actors associated with "the co-evolution of technologies, institutions, business strategies and, also, user practices" and can be defined as highly qualitative in nature. The storylines were developed from the multi-level perspective of transition dynamics (Kemp, 1994; Geels, 2002) taking in the political, social and cultural landscape, socio-technical regimes and technological niches. The project's conceptual and analytical framework lays out the full argument for this methodology and approach (Foxon, 2008).

For the purpose of numerical and empirical examination it was necessary that these qualitative *storylines* were quantified. Quantification was undertaken by an interdisciplinary team working to create numerical descriptors as well as expand and develop the transition pathway *storylines*. This paper presents an iterative approach to the quantification of the pathways, which takes account of the socio-political drivers for the pathways to develop quantitative descriptions that are coherent and consistent with the qualitative *storylines*.

Quantitative storylines are those identified as having little or no qualitative drivers or descriptors (Fortes et al., 2015) and although technically rigorous, they typically lack the inclusion of social actors, thus weakening the robustness of insights (Söderholm et al., 2011). The method proposed herein for the quantification of qualitative storylines increases robustness of findings by adding depth of knowledge to a greater breadth of understanding, and by placing the work in an interdisciplinary context. Drawing on expertise and insights from many disciplines adds greater credibility to analysis, with contributions from multiple fields of study. Consequently, better insights could be drawn and smaller nuances be recognised and then investigated.

This methodology for quantification of qualitative storylines has similarities to the SAS (story-and-simulation) approach to scenario development (Alcamo, 2001; Alcamo, 2008). However a key disadvantages of the SAS approach is the time and money overhead for organisation and workshops etc. and a necessity for a dedicated team to be cycling though the methodology stages. The methodology proposed by this paper instead runs in parallel to, and is significantly complemented by, a greater field of (interdisciplinary) exploration and analysis of storylines and the related fields. Iterations of quantifications are performed alongside other (consortium) research, by an existing team who are already embedded in the landscape of the storylines and therefore able to make deployments across the breadth of the storylines as well as at depth in their respective specialisms.

Trutnevyte et al. (2014) discusses the landscape of models within the Realising Transition Pathways consortium and the process of linking those models to transition pathway storylines in an effort to improve them both. The work of this paper builds on this effort and presents a formal approach to storyline quantification: the iterative approach, to 'bridge' this gap further and provide an approach that can be applied by others. This methodology works to create a technologically feasible quantification of a qualitative storyline whilst staying true to its central philosophy. Trutnevyte et al. (2014) identified that the process and product of scenario analysis are equally important. Energy transitions are very complex and through the interdisciplinary quantification of a storyline there is a transfer of knowledge. It is asserted that this formal process helps build robust future scenarios not only for socio political *storylines* but also for the quantification of any qualitative storyline.

The remainder of this paper will begin in Section 2 by introducing then describing a methodology for the quantification of qualitative storylines. Section 3 then details the results of the application of the methodology to the *transition pathway* qualitative storylines over two iterations including results from an investigation stage. Section 4 discusses the results detailing the improvements the iterative approach facilitated and finally Section 5 concludes.

2. Methodology

2.1. Introduction

A four stage interdisciplinary methodology was developed by the RTP consortium for the quantitative elaboration of the transition pathways storylines. This methodology expands on previous work carried out in the consortium (Barnacle et al., 2013), providing a formal process for the quantitative component of the complete (both qualitative and quantitative) elaboration of social-technical scenarios. This framework