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Opening the Black Box of Energy Security: A Study of Conceptions of Electricity Security in the UK

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Opening the black box of energy security: a study of conceptions of electricity security in the UK

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Abstract

Despite much literature on energy security, the term continues to resist a commonly-accepted definition. Nevertheless, policy decisions are frequently made on the basis of 'improving energy security', despite the lack of any clear understanding of what improving energy security actually means. Therefore this paper explores the meaning of energy security for key experts in the UK energy sector, with a particular focus on the security of electricity systems in the context of a low-carbon transition. A set of 22 energy security indicators is discussed with 25 experts from across the energy sector in the UK, in order to get a grasp on which aspects or dimensions of energy security are felt to be most important, and to discover the underlying concepts which are used by experts when making or justifying these choices. The results from the interviews show that there is a real need to attempt to take into account multiple competing and context-specific views on energy security, instead of trying to close the discussion down around a small number of simple quantifiable indicators or metrics. The results also show that there is no alignment between experts' perspectives and the organisation or constituency for which they work.

Keywords: energy security; perceptions; low-carbon transition; electricity; UK energy policy

1. Introduction

The term 'energy security' has become commonplace in both academic and policy discussions. However, there exists a considerable array of overlapping and competing conceptualisations, and despite much literature on the subject the term resists a commonly-accepted definition (Ang *et al* 2014; Blumer *et al* 2015; Chester 2010; Gracceva and Zeniewski 2014; Sovacool 2011). Nevertheless, energy security has become a key driver and justification of much energy policy in recent years, driven by concerns over resource nationalism and instability in key export regions such as the Middle East, China and Russia, concerns over fossil resource concentration, and increasing pressure on energy systems to undergo a fundamental tyransitoln in order to reduce carbon emissions (Bielecki 2002; Blumer *et al* 2015; Cherp and Jewell 2011; Froggatt and Levi 2009; Kuzemko 2014; Sauter and MacKerron 2008). Therefore this paper conducts an empirical exploration of the meaning of energy security for key experts in the UK energy sector, with a particular focus on the electricity system in the context of a low-carbon transition. The aim is to get a grasp on what aspects or dimensions of energy security are felt to be most important, and to discover the underlying concepts which are used by experts when making or justifying these choices. This paper thus aspires to generate an in-depth and transparent discussion which does not seek to close down the diversity of views, but instead seeks to open them up to debate and to policy attention.

As shall be elaborated in the following section, energy security is inherently context-specific, therefore it makes sense for the analysis to focus on one specific country (Blumer et al 2015). The UK is chosen as a case study because its energy system is in a major period of transition, driven by a number of factors. The UK is entering a new phase of net fossil fuel imports due to declining domestic production, which has increased policy concerns regarding resource nationalism and resource concentration globally (Kuzemko 2014; MacKerron 2009). The electricity supply infrastructure is ageing and will require around 19GW of electricity supply capacity to be replaced by the mid-2020s; the retirement of older fossil fuel power plant capacity has led to an erosion of capacity margins in the power sector (DECC 2011; Ofgem 2012). Additionally, the UK is under pressure to decarbonise its energy system: the 2008 Climate Change Act established the world's first legally-binding climate change target (DECC 2008). These multiple issues have meant that energy security has risen extremely rapidly up the public and policy agenda in the UK in recent years, and unlike many other European countries, the UK has a specific energy security strategy (DECC 2012a). Nevertheless, many other industrialised countries, both in Europe and further afield, are experiencing similar pressures on their electricity systems, meaning that the UK can act as a useful basis for exploring electricity security in other national contexts.

The following section of the paper introduces the literature on energy security, with a focus on conceptualisations of energy security and the evolution of the term in recent years, and also introduces the case study of the security of electricity systems in a low-carbon context upon which this paper is based. Section 3 then outlines the methodology used for conducting and analysing interviews with energy experts. Section 4 presents the results in two parts: firstly focusing on seven central themes which were identified from the qualitative interview data, and secondly focusing on the quantitative results and the question of alignment between respondents' views and the constituency in which they work. Section 5 discusses and analyses the results in more detail and identifies possible implications, and also outlines some limitations of the study and areas for further research. Finally, section 6 concludes and offers recommendations for policy.

2. Literature review

2.1 Conceptualising energy security

As Sovacool (2011) points out, energy itself is a politicised and multifaceted topic, with occasionally incommensurable views rooted in diverse disciplines such as physics, economics, engineering, ecology, sociology and politics. There are some widely-cited definitions available, including that of the International Energy Agency (IEA 2015) which states that energy security denotes "the uninterrupted availability of energy sources at an affordable price". However, as pointed out by Müller-Kraenner (2007), when it comes to such definitions the devil is in the details: for instance, what exactly do we mean by 'affordable'? In an analysis of existing definitions and conceptualisations of energy security, Lynne Chester finds that:

> An examination of explicit and inferred definitions finds that the concept of energy security is inherently slippery because it is polysemic in nature, capable of holding multiple dimensions and taking on different specificities depending on the country (or continent), timeframe or energy source to which it is applied. (Chester 2010: 887)

This 'slipperiness' means that the concept is open to exploitation by interest groups, and is frequently used to justify various policies simultaneously, even if these policies appear to be contradictory (Löschel *et al* 2010). Energy security has no core underlying objective reality; it is an arena in which different voices seek to securitise their particular understanding of key risks and threats (Buzan *et al* 1998; Kuzemko 2014). As pointed out by Joskow:

> There is one thing that has not changed since the early 1970s. If you cannot think of a reasoned rationale for some policy based on standard economic reasoning then argue that the policy is necessary to promote 'energy security.' (Joskow 2009, cited in Winzer 2011)

Compounding this is the fact that conceptions of energy security are highly context-dependent, and are strongly correlated with national energy policies and state imperatives (Ang *et al* 2015; Bielecki 2002; Toke and Vezirgiannidou 2013). A cross-national survey of energy users from 10 countries found that alongside generally high concern for energy security, demographic and national characteristics have a very significant role to play (Knox-Hayes *et al* 2013; Sovacool *et al* 2012). In a separate study, Pasqualetti (2011) surveyed 40 energy security specialists from around the world, and found that certain concerns which appear high on the agenda in one nation won't necessarily matter for another. Moreover, it has been shown that energy security concerns are dynamic and evolve as circumstances change over time, reflecting dominant discourses and political economic trends (Ang *et al* 2015; Dannreuther 2015; MacKerron 2009); as noted by Dannreuther, "The broader context of the global political economy has a determining effect on which particular securitization of energy assumes dominance" (2015: 467). Finally, a Swiss study by Blumer *et al* (2015) found distinct differences between energy users and energy experts when conceptualising energy security, particularly involving differences in the timescales of reference being drawn upon.

Energy security is frequently viewed as one aspect of the 'energy trilemma', which states that sustainable energy should be secure, affordable and low-carbon (E.on 2008). The 'trilemma' framework has grown in use in the UK in recent years, and has become one of the keystones of UK energy policy (see for example DECC 2012a; 2014). However, although the trilemma framework views security of supply as a discreet goal, to be traded off against affordability and low-carbon goals, the literature on energy security has actually broadened out to include both affordability and environmental concerns, in part as a response to emerging normative, legislative and legal imperatives to cut carbon emissions (Elkind 2010; IEA 2011; Kruyt *et al* 2009; Logan and Venezia

2007; Narula and Reddy 2015; Symons 2011). Such broadened perspectives have been used widely in the more recent energy security literature and as the basis for a number of empirical assessments (eg Francés *et al* 2013; Hughes 2012; Mitchell *et al* 2013; Pfenninger and Keirstead 2015; Sovacool and Brown 2010). However, there have been few attempts to explore conceptualisations of energy security in a low-carbon context, and to attempt to identify which aspects of 'security' are prioritised by energy experts when considering the imperative to meet affordability and low-carbon objectives.

2.2 Case study: The security of low-carbon electricity systems

The security of electricity systems is an important case study because of the central nature of electricity systems to society, not only in the UK but everywhere in the world. Projections suggest that electricity will be the fastest growing energy sector in the future (IEA 2014), and electricity and heat production is the largest single source of greenhouse gas emissions globally (IPCC 2014). Efforts are already underway to electrify heating and transport systems in order to make deeper cuts to emissions from these sectors in the future, meaning that findings relating to electricity security could eventually become a key component of efforts to decarbonise heating and transport. Chester (2010) therefore makes the point that energy security studies should acknowledge the importance of electricity, rather than focusing on oil and gas. However, the picture becomes even more complex when discussing the security of electricity systems, as opposed to security of primary fuels. On the one hand, conceptions of 'energy' security often take a very large-scale, long-term view, focusing on issues such as geopolitics, resource depletion and climate change (e.g. Bielecki 2002; Bordhoff *et al* 2010; IEA 2007; Kruyt *et al* 2009; Martchamadol and Kumar 2013; Müller-Kraener 2007; Yergin 2006); these conceptions are usually rooted in social science disciplines such as economics and international relations (Cherp and Jewell 2011). Meanwhile on the other hand, conceptions of 'electricity' security often take a micro-scale, short-term view, focusing on issues such as capacity margins and grid balancing (e.g. Chaudry *et al* 2011; Creti and Fabra 2007; Jamasb and Pollitt 2008; Paulus *et al* 2011; Ofgem 2011); these conceptions are usually rooted in physical science disciplines such as engineering (Cherp and Jewell 2011). Electricity is therefore an interesting case in that it encompasses the range of disciplines within which energy security is rooted, as well as the full range of timescales across which energy security operates.

2.3 The importance of understanding conceptions of electricity security

It is clear that when discussing energy systems, security continues to mean different things to different people, and the carbon reduction imperative further complicates this picture. One of the challenges of energy security policy lies in the need for policy to at least attempt to take into account the multiple perspectives of the energy community. However, as of yet, the diversity of views remains vague and intangible, and policy decisions are frequently made on the basis of improving energy security without any attempt to discover what aspects of such a broad and polysemic topic are actually important or material (for example, DECC 2012a; DECC 2013a; DECC 2013b; DECC 2014). The majority of the existing work on conceptualisations has focused on existing literature and policy documents, with the notable exception of the papers mentioned earlier which carried out surveys and/or interviews (Blumer *et al* 2015; Knox-Hayes *et al* 2013; Pasqualetti 2011; Sovacool *et al* 2012). Considering that security concerns are highly correlated with national contexts, it would be useful to explore conceptions of energy security *within* particular national contexts (as suggested and operationalised in the Swiss context by Blumer *et al* [2015]), in order to discover what aspects of energy security are felt to be most important to key experts within a policy jurisdiction, and to assess empirically the question of what energy security actually means within that jurisdiction. In this way, instead of simply stating that 'energy security means different things to different people', it becomes possible to get a grasp on actual perspectives, exploring in particular the existing policy context of the imperative for a secure, affordable and low-carbon system.

3. Methodology

3.1 Interview methodology

Semi-structured face-to-face interviews were conducted with 25 experts from the UK energy sector. The interviews asked the participants to give their opinions on a set of pre-defined indicators for the security of an electricity system in the context of a low-carbon transition, following a similar methodology to Sovacool *et al* (2012). 22 indicators in total were selected from an in-depth review of the existing literature; the indicators and literature from which they emerged is shown in Table 1. Indicators were chosen to reflect a broad understanding of security, including aspects of environmental sustainability and societal concerns (Elkind 2010; Francés *et al* 2013; Logan and Venezia 2007; Narula and Reddy 2015), in order to interrogate the extent to which the experts agreed with this broader understanding.

The purpose of interviewing experts rather than simply energy users is an attempt to explore the views of those who a) have existing knowledge of energy and energy security and the complexities therein, and b) may have some influence on policy processes, through direct involvement or participation in research and consultations. Experts were selected from a range of different constituencies within the UK energy sector, in order to gather a range of views from across the spectrum of potentially influential energy experts, and in order to identify any patterns or alignments which emerge within or between constituencies. Six desired constituencies were identified:

1. Utilities (e.g. the Big Six energy suppliers, smaller suppliers, industry representation groups)
2. Non-Government Organisations (NGOs) and civil society (e.g. consumer interest organisations, energy co-operatives)[1]
3. Think tanks, consultancies and consortia
4. Policy and regulation (e.g. government departments, Ofgem)
5. Networks (e.g. the National Grid, the Distribution Network Operators)
6. Academia (e.g. universities, research groups)

Multiple interviewees were selected from each of these constituencies, with the overall aim of interviewing a diverse range of experts in the energy sector. The interviewees were selected using non-probability sampling (see Tansey 2007). Initially, purposive sampling was used to contact respondents from a number of target organisations. Secondly, snowball sampling was used to fill in any gaps in organisations or constituencies where purposive sampling failed to get a response from the desired individual or organisation.

About one week before each interview, respondents were sent a 2-page briefing note, consisting of an introduction and overview of the research, and the list of indicators (see Appendix A). During the hour-long semi-structured interviews, participants were asked to discuss each of the indicators in turn, and to state how important or material they felt each indicator is for the

[1] Energy co-ops could technically be viewed as either 'NGOs' or 'utilities'. However, in light of the fact that employees of energy co-ops are often ideologically driven, and frequently work as volunteers for many years without earning a wage from the organisation, it was decided that they have more in common with other civil society actors than with the utilities.

security of a low-carbon electricity system, and why. They were also asked to rank each indicator on a Likert scale from 1 to 5 (with 5 denoting 'critical importance' and 1 denoting 'minimal importance'), in order to elicit quantitative as well as qualitative data. Finally, interviewees were asked to talk more generally about what they see as the main risks for UK electricity security in the short, medium and long-term, and what measures they feel are most important for maximising security in a low-carbon context.

In order to analyse the data from the semi-structured conversations, the interviews were transcribed in full and the transcripts were coded in accordance with recognised methods for thematic coding analysis (Braun and Clarke 2006; Burnard *et al* 2008; Hsieh and Shannon 2005). This method of analysis identifies key words and topics, which are gradually grouped and ordered to find areas of commonality or repetition and to identify a manageable set of themes. For the purposes of this study, themes were identified which were cross-cutting across both multiple participants *and* multiple security indicators and dimensions.

Table 1: List of indicators used as basis for interviews, including relevant literature

	Indicator	Relevant literature
"Availability"	Public approval	Axon *et al* (2013); Demski *et al* (2013); Falk (2011); Hayashi and Hughes (2013); Whitmarsh *et al* (2011)
	Public participation	Barton *et al* (2015); Bell *et al* (2005); Cohen *et al* (2014); Fast and Mabee (2015); Johansson (2013); Jones and Eiser (2009; 2010); Sovacool *et al* (2012); Warren and McFayden (2010)
	Direct opposition	Axon *et al* (2013); Batel *et al* (2013); Burningham *et al* (2006); Cherry *et al* (2014); Cohen *et al* (2014); Devine-Wright *et al* (2009); Devine-Wright (2005); Greenberg and Truelove (2011)
	Diversity of fuel types	Axon *et al* (2013); DECC (2012a); Grubb *et al* (2006); Jewell *et al* (2014); Lehr (2009); Pfenninger and Keirstead (2015); Stirling (1998)
	Import dependence	Axon *et al* (2013); Frondel and Schmidt (2014); IEA (2011); Jewell *et al* (2014); Kruyt *et al* (2009); Le Coq and Paltseva (2009); Pfenninger and Keirstead (2015); POST (2012); Umbach (2010); Victor *et al* (2014)
	Import diversity	Axon *et al* (2013); DECC (2012a); European Commission (2014); Frondel and Schmidt (2014); IEA (2007); Kruyt *et al* (2009); Jewell *et al* (2014); Jonsson *et al* (2015); Neumann (2007)
	Import stability	Axon *et al* (2013); Frondel and Schmidt (2014); IEA (2007); Jonsson *et al* (2015); Kruyt *et al* (2009); Le Coq and Paltseva (2009); Lilliestam and Ellenbeck (2011); Neumann (2007)
"Affordability"	Annual electricity bills	Centrica (n.d.); DECC (2013c); Elkind (2010); Hughes (2012); IEA (2007); Kruyt *et al* (2009); Sovacool (2011); Sovacool *et al* (2012); Sovacool and Brown (2010)
	Levelised cost of generation (LCOE)	Centrica (n.d); DECC (2012a; 2013d); Greenleaf *et al* (2009); Hayashi and Hughes (2013); Kruyt *et al* (2009); Mott MacDonald (2010); Pfenninger and Keirstead (2015)
	Cost of distribution upgrades	Bolton and Hawkes (2013); Boston (2013); Greenpeace (2005); Jamasb and Pollitt (2008); Pudjianto *et al* (2013)
	Cost of transmission upgrades	Bolton and Hawkes (2013); Boston (2013); Electricity Networks Strategy Group (2012); Jamasb and Pollitt (2008); National Grid (2011; 2013b); Strbac *et al* (2014)
	Fuel poverty	Axon *et al* (2013); Barton *et al* (2015); Hills (2012); Mitchell and Watson (2013); Sovacool (2011); Sovacool *et al* (2012); Sovacool and Brown (2010)
"Environmental Sustainability"	Carbon emissions	Axon *et al* (2013); Bollen *et al* (2010); Elkind (2010); Falk (2011); Hughes (2012); IEA (2007); Ladislaw *et al* (2009); McCollum *et al* (2011); Sovacool *et al* (2012); Sovacool and Brown (2010); Winzer (2011)
	Fuel depletion	Axon *et al* (2013); Asif and Muneer (2007); Capellan-Perez *et al* (2014); Kruyt *et al* (2009); Kuzemko and Bradshaw (2013); Mitchell and Watson (2013); Nuttall and Manz (2008); POST (2012); Sovacool (2011); Sovacool *et al* (2012); Watson (2010); Winzer (2011)
	Materials depletion (Rare Earths etc)	Gholz (2014); Humphries (2013); Krishna-Hensel (2012); Moss *et al* (2011); Speirs *et al* (2014); Stegen (2015); Umbach (2012)
	Water usage	Carrillo and Frei (2009); Davies *et al* (2012); King *et al* (2008); Koch and Vögele (2009); Kyle *et al* (2013); McDermott and Nilsen (2012); Sovacool *et al* (2012); Van Vliet *et al* (2012)

"Reliability"	De-rated capacity margins (DRCM)	DECC (2011; 2012a); Greenleaf *et al* (2009); House of Lords (2015); National Grid (2012); Newbery and Grubb (2014); Ofgem (2011; 2012); RAEng (2013)
	Oversupply	Barnacle *et al* (2013); Barton *et al* (2013)
	Response and reserve	EirGrid/SONI (2011); Kiriyama and Kajikawa (2014); National Audit Office (2014); National Grid (2011); Ruttledge and Flynn (2015); Strbac *et al* (2012a)
	Flexible demand	Bolkesyø *et al* (2014); DECC (2012a); Dudeney *et al* (2014); Drysdale *et al* (2015); Energy and Climate Change Committee (2011); E3G (2014); Mitchell and Watson (2013); Nistor *et al* (2015); Strbac *et al* (2012a)
	Electricity storage	Grünewald (2012); IMechE (2012); Strbac *et al* (2012b); World Energy Council (2008)
	Interconnection	European Council (2011); House of Lords (2015); National Grid (2013a); Newbery *et al* (2013); Strbac *et al* (2012a); World Energy Council (2008)

4. Results

4.1 Qualitative results: seven major themes

Seven key themes emerged from the thematic coding analysis of the interview transcripts. These themes were identified because they were mentioned by several interviewees (usually from a number of different constituencies), and because they were mentioned in relation to a number of different indicators and different dimensions. These themes have been used to create seven guiding statements, presented in parentheses at the beginning of each sub-section. The first three themes discussed here (sections 4.1.1 to 4.1.3) represent areas in which there was lots of contention between different respondents on a particular issue; the following four themes represent areas in which the majority of the respondents were in agreement (sections 4.1.4 to 4.1.7).

4.1.1 How broad is too broad?

"Respondents are split over what is important or material for energy security, especially regarding 'affordability' and 'environmental sustainability', possibly due to different criteria being used as the basis for viewpoints."

The interview discussions highlighted the fact that there are major challenges in assessing the security of an energy system because of high levels of disagreement over what is important or material for ensuring energy security, in accordance with the literature discussed in preceding sections. This factor is further complicated by the addition of the carbon reduction imperative. There was considerable disagreement amongst the respondents as to what actually constitutes energy security, with roughly half of the respondents believing that affordability and environmental sustainability are integral to electricity security, whilst others believed that these are separate issues and should be thought of as trade-offs. It is interesting to compare this to debates in the literature: opinions are somewhat divided over whether environmental sustainability should be viewed as an aspect of energy security (see for example Ang *et al* 2015; Dannreuther 2015; Elkind 2010; IEA 2011; Kruyt *et al* 2009; Luft *et al* 2011; Narula and Reddy 2015; Toke and Vezirgiannidou 2013), but the majority of widely-cited definitions include the affordability dimension (eg Bielecki 2002; Kruyt *et al* 2009; IEA 1985; IEA 2007; Yergin 2006).

This disagreement over what is important or material for assessing security manifested itself noticeably in considerable contention over the majority of the indicators. The transcripts revealed that different participants seemed to be using different criteria for basing their responses. The two main viewpoints were:

a) The important indicators are those which we have an imperative to address, either for normative reasons or because they represent a current or future risk (according to the subjective viewpoint of the respondent)
b) The important indicators are those which are simple, direct and/or quantifiable.

A good example of this can be found in the responses regarding the most contentious indicator, 'fuel poverty'. Respondents who felt that fuel poverty is critically important for energy security mostly felt that it represents a real problem in the UK, and therefore felt that improving energy security will necessitate mitigating fuel poverty. For example:

> You need to be affordable. Fuel poverty itself is a bit of a moveable feast how you assess it, but you can't really run an energy system where the poorest in the country can't afford to access. (Respondent Q)

> Fuel poverty I would put that as pretty important, because that's where you see the most potential to engage the public and there's a lot more of a moral argument. (Respondent M)

On the other hand, several respondents stated that fuel poverty is too indirect and complex to act as a material part of a conceptualisation or assessment of energy security. For example:

> I don't think that there is a connection between fuel poverty and energy security. I mean, you could stretch it I suppose... But I'm going to say that it's not a part of energy security, it's part of something different. (Respondent K)

> Well the thing about fuel poverty is, it's actually shown almost no ability to influence the politics of energy over quite some time. I mean there's quite a lot of pious commentary about it, but very little real kind of gritty attack on it. I suspect it's because a lot of those people who are genuinely fuel poor don't vote. (Respondent C)

This split between different criteria being used as the basis for viewpoints was also apparent in discussions regarding a large number of other indicators, particular in the affordability and sustainability dimensions. Meanwhile, simplicity and directness were commonly given as key reasons for the materiality of traditional indicators such as de-rated capacity margins (DRCM), diversity and import dependence. This is a rather preliminary finding, which would warrant further investigation in future research.

4.1.2 'Traditional' indicators

"Respondents do not agree with each other on the importance of some indicators which are traditionally used to assess energy security such as import dependence and diversity; it is important to look beyond the 'availability' dimension."

This second theme also relates to respondents' views regarding how to conceptualise energy security. Two indicators which have often been used in the literature to assess energy security are dependence on imports, and diversity (eg DECC 2012a; Frondel and Schmidt 2008; IEA 2011; Jewell *et al* 2014; Kruyt *et al* 2009; Pfenninger and Kierstead 2014; Victor *et al* 2014). The literature often refers to 'reducing control' by others, or limiting the ability of fuel-exporting nations to gain political leverage through their exports (Bordhoff *et al* 2010; Greene 2010; Umbach 2010). However, there is also considerable scepticism over the security benefits of minimising fuel imports (Chaudry *et al* 2011; Francés *et al* 2013; Stern 2004; Watson 2010). Elsewhere, some suggest that diversity acts as a vital hedge against unpredictable supply and price disruptions (Bradshaw 2010; Cooke *et al* 2013; Grubb 2006; Hoggett 2013; Stirling 1994; 1998; Urciuoli *et al* 2014; Watson 2007; Watson and Scott 2008). However, it is also noted that an amount of diversity may well be a necessary feature of a secure energy system, but that it is not sufficient to ensure energy security by itself (Christoff 2011; Gracceva and Zeniewski 2014; Ranjan and Hughes 2014; Stirling 2010). Some respondents were very sceptical about the usefulness of these two indicators; for example:

> It's one of these dogmas at the minute, that everyone says, "future system - diverse, diverse, diverse". I'm less sure about that. I look at France for example, that has what seems to be a very secure system, has been for years and years, and it's about as un-diverse a system as you could get. You need a mix that works... (Respondent A)

> To say 'we can't rely on those pesky foreigners' is an attitude that's kind of dodgy anyway, it assumes every other country in the world is ganging up against us, basically paranoia (Respondent Q).

Many respondents also echoed the idea that these indicators are necessary but not sufficient to capture all the important aspects of energy security. However, there was also disagreement on this point, with many respondents stating that aspects such as import dependence and diversity are some of the major things which spring to mind when they consider energy security. Several respondents also spoke of the need to hedge against unpredictable risks by reducing dependence or by increasing diversity. For example:

> To me, this is the nub of the debate. We can't plant the whole of the decarbonisation agenda on one technology, only to find out it can't be deployed or we've misunderstood public acceptability, or we can't get cost reduction. (Respondent V)
>
> You can't control what another country's going to do. So you're increasing risk by relying on imports. And from a business point of view, you want to mitigate, to minimise the risk. So I suppose you're increasing instability by getting it abroad, to various degrees. (Respondent T)

It is interesting to note that both these indicators are in the 'availability' dimension, primarily referring to physical supplies of electricity and/or fuels. Therefore the disagreement over these traditional indicators suggests the need to look beyond this dimension, for instance towards indicators relating to reliability and flexibility: the electricity supply needs to be able to reliably meet demand under normal operating conditions, and also to be able to respond in a timely manner to unexpected changes in the supply/demand balance.

4.1.3 Are the lights going out?

"Respondents do not agree with each other over the current level of risk to the UK electricity system, but how risks are framed and perceived is just as important."

A common theme arose regarding current risks to electricity security, and whether or not the UK really is in danger of a serious supply disruption in the near future. On this, there was quite a lot of disagreement. This disagreement is reflected in the literature, which gives somewhat mixed messages about the actual level of risk of a severe supply disruption in the UK (see for example DECC 2014; House of Lords 2015; National Grid 2015; RAEng 2013). Some respondents felt that the UK system is not currently resilient enough to certain risks such as storms, and that a major outage is likely sometime in the near future. Not everyone agreed on this, but there was consensus that a big unplanned interruption could have a major impact on energy policy, and possibly on the legitimacy of the transition. Respondent S said:

> If there are more outages, if the lights go out, the public won't accept the policies going forward. They'll say that's a failure of policy, and then you're gonna have to change radically, and some of those changes could fundamentally contradict the direction you're currently taking.

Several respondents agreed that the most important outcome in the event of a major disruption would be who got the blame: if the public perceived that low-carbon energy was to blame, this could seriously derail attempts to decarbonise the electricity system. There is relatively little in the literature on this topic, although the issue is mentioned in RAEng (2014). On the other hand, a large number of respondents argued that the risks to electricity security have been overplayed, noting that demand is going down and that the UK is in a relatively secure position, but that politicians are nervous about the idea of the lights going out and therefore tend to exaggerate the risks. One said:

> I think the risk has been overplayed… Politicians are overly accountable which makes them err on the side of caution too much. (Respondent D)

Many respondents noted that energy security as a term or concept is utilised by many different stakeholders as part of their negotiating or influencing position, even if they don't actually believe that the lights are going to go out, as also noted by Buzan *et al* (1998); Joskow (2009, cited in Winzer 2011) and Löschel *et al* (2010).

4.1.4 Difficult Choices

"Difficult decisions must be made over which part of the energy trilemma to prioritise, and we may need to challenge the current predict-and-provide model of electricity provision."

It was frequently noted by the respondents that several of the measures for improving the security of an electricity system would be unviable or more complicated in the event of a low-carbon transition; this echoes the literature which discusses the trade-offs which may occur between carbon reduction and security imperatives (eg Boston 2013; Froggatt and Levi 2009; Hughes and Ranjan 2013; Johansson *et al* 2014). There was no consensus on whether one particular side of the energy 'trilemma' should be prioritised; however, it was frequently suggested that the biggest risk from a political perspective would be the cost of achieving the transition, and whether or not people would accept those costs. As stated by respondent N:

> If supply costs get so high that people can't pay their bills then that is going to have a negative impact on security of supply and you will also end up with political things happening that will then destabilise things.

Many respondents suggested that the political reality would be that decarbonisation would probably be sacrificed first, before security and affordability, especially in the event that there was either a serious risk of the 'lights going out' or a noticeable increase in costs. One respondent said:

> …ultimately when people make decisions about the trilemma, this [carbon emissions] is the one that gives up in preference to security of supply. But this is the one that we actually have a legal obligation to do, whatever that means. (Respondent W)

Thus respondents felt that the transition will involve making difficult choices, both for policy-makers and the public. This supports the literature which suggests that the decarbonisation agenda is becoming more problematic and divisive for UK policy-makers (Carter 2014; Carter and Clements 2015; Corner 2013; Foxon and Pearson 2013; While 2013). However, the policy literature continues to talk of achieving a balanced trilemma and tends to play down the idea of difficult choices, probably because of the legally-binding nature of the carbon targets (DECC 2012a; 2012b; 2014).

Another area in which many respondents noted the difficult choices ahead was regarding possible sacrifice of the UK's high reliability standard for electricity. Although electricity security is commonly conceptualised as supply continuing to meet demand at all times of the day, a number of respondents questioned whether this is realistic or desirable in the context of a highly challenging low-carbon transition. There was consensus amongst the respondents that the UK currently has a very asymmetrical system, in which people expect their supply to be continuously available (the 'predict-and-provide' model). Several respondents suggested that in a context of increased penetration of intermittent generation, consumers could be required to accept a more flexible form of demand, for instance a system in which demand follows supply rather than the other way round. In the words of two of the respondents:

> I just think that you can organise your electricity system in different ways, so that you don't have to have that peak, so you don't have to be so far in excess of that peak. I suppose because I'm old enough to have lived when the lights went out from time to time, I lit a candle and read a book. But governments have to be

> concerned about the public's response, and the public is not used to power cuts anymore. We're all spoilt, aren't we? (Respondent B)

> …this has become the default criteria for energy security - the lights don't go out. And no politician is going to try to tackle that idea... So it's almost like a default position, you can't discuss energy security, without the proverbial lights go out. I suppose politically it is very difficult for anybody to challenge the idea that energy supply might be less. (Respondent T)

The potential benefits of demand-side flexibility are echoed in the considerable literature on demand-side response (see for example DECC 2011; Dudeney *et al* 2014; Hoggett *et al* 2013; Lockwood 2014; Strbac *et al* 2012a); however, the literature generally stops short of the respondents' suggestion that consumers may be required to accept a shift away from the current predict-and-provide model. Several respondents also suggested that politicians are currently too accountable for losses of supply, which makes them err on the side of caution, and makes it highly unlikely that they will be willing to broach the subject of changing the way in which consumers in the UK use electricity (also noted in Newbery and Grubb 2014; RAEng 2014). This could to some extent explain the slight mismatch between much of the literature and the slightly more 'radical' solutions suggested by the respondents. There was also consensus amongst the respondents of the need for better public engagement around how difficult it will actually be to achieve the three aims of the energy trilemma simultaneously; respondent I said:

> I think there's a huge role for politicians and the wider civil society to engage the public in the debate, so the public is better able to make informed choices. I think that ultimately the public choices are everything, but there should be an opportunity to engage with the public in a meaningful way, and to maybe challenge some conceptions at times, but also to inform.

This perspective is echoed by the House of Lords Science and Technology Committee (House of Lords 2015: 5), who suggest that the public has not been "sufficiently informed" of the scale of the challenge, although the extent to which policy-makers will act on this advice remains to be seen.

4.1.5 Economic and political feasibility

"Energy security depends on securing adequate investment, which depends on political stability."

One of the most common cross-cutting issues amongst the respondents was the importance of securing adequate investment. A majority of respondents noted this as one of the most critical aspects of ensuring energy security on all timescales, and there were concerns that the UK (and in fact much of the EU) is currently at risk of a lack of investment in energy infrastructure (see for example Blyth *et al* 2014; Deane *et al* 2015; Ellenbeck *et al* 2015; Mitchell *et al* 2014; Usher and Strachan 2012). There was consensus that in order for this to happen, investors must be given long-term assurances that their investments will pay off. There was a common perception amongst respondents that there is currently a lack of political certainty, especially over whether to prioritise certain parts of the trilemma and the fate of the UK's decarbonisation targets as the transition becomes more challenging. As stated by two respondents:

> There has to be a conversation about it, and it really needs to come from the top down, it needs to be made clear that we've got to do something about climate change and this is what we are doing, take it or leave it. (Respondent F)

> The plan… There isn't technically a plan. The carbon target, that's 2050 as we know, but there will need to be plans in order to achieve the transition because right now we don't really have one beyond 2020. (Respondent U)

Some respondents went a step further and stated that this political feasibility would only be achievable in the context of a 'social contract' for the transition; in other words, shared norms and ideals which underlie broad public acceptance for a transition to a low-carbon electricity system. This idea is well grounded in the existing literature; see for example Ekins *et al* (2011); Foxon (2012); Mancebo and Sachs (2015); Messner (2015); WGBU (2011). Respondent O said:

> I do think that this social contract aspect of sustainability is important, which is that if you want to maintain security you will need to invest and if you need to invest than you do need to have the confidence that the public will come with you and I think your risk of not having that buy-in becomes quite core.

4.1.6 Context

"The choice of indicators depends on the spatial context and the degree of decentralisation."

Another major cross-cutting theme which emerged was that of the importance of context. Spatial context was felt to be very important by many of the respondents, because some measures can be highly beneficial for electricity security in certain locations, but can generate insecurity if located in the wrong places. It is interesting to compare this to a tendency in the literature to attempt to make security assessment frameworks as universal as possible (see for example Deane *et al* 2015; Gracceva and Zeniewski 2014; IEA 2007; Jewell *et al* 2014; World Energy Council 2012). Furthermore, a large number of respondents felt that the level of decentralisation is critical for security and for the relative importance of the indicators. As suggested by respondent W:

> You can conceive of a radically different vision of the future; a very decentralised world where most energy is being generated locally with local storage and lots of local micro grids with loose interconnection. What determines local security of supply in that world?

These distinctions could create challenges for designing a generic framework for comparing the security of different scenarios or different national contexts, because it could be that many indicators are better suited for assessing the security of one or the other. The results from the interviews therefore raise questions over the extent to which it is desirable or practical to attempt to create generalisable frameworks for assessing the security of energy systems, especially when attempting to achieve generalisability on a global scale.

4.1.7 The demand side

"Realising the potential co-benefits of flexible demand, demand reduction and energy efficiency is crucial."

In the literature, flexible demand, demand reduction and energy efficiency are commonly cited as 'win-wins' for the trilemma, because in theory they can reduce costs and emissions at the same time as making it easier to keep the system secure, as suggested by Adelle *et al* (2009); Berk *et al* (2006); Froggatt and Levi (2009); Greenpeace (2010); Hoggett *et al* (2013) and Pye *et al* (2014). This was echoed by a large number of respondents, who mentioned the importance of demand reduction and demand flexibility in relation to a large number of indicators. For example, one said:

> We've had this very active supply side since the beginning of the utility industry; what's been idle is the demand side. If management of demand gets more involved, I think that's the key. So as a priority, I would say the demand side, because we pretty much already have all the tools on the supply side. (Respondent M)

The most important issue to the respondents seemed to be the potential co-benefits of measures to reduce demand. Reduction of overall energy demand can in theory improve reliability, availability, affordability and sustainability. Some respondents also saw increased action on the demand-side as a potential means of improving public acceptability of the transition. As stated by one respondent:

> If you are going down a strategy which involves more diffuse tech such as renewables, demand-side response etc, you will probably need a lot more participation and engagement as you need consumers to be interested to shift tariffs, and people to be happy to have new forms of energy infrastructure that they're not so familiar with, closer to their homes or communities. (Respondent D)

However, it was also noted that:

> There's a strong, almost ideological opposition to the idea that we should think about anything to do with our demand – we have a right, we pay our electricity supplier for our electricity, and that instils a right, a sense of a right, to use as much as we feel we need. That fundamental assumption, I think, we have to challenge. (Respondent X)

4.2 Quantitative results

Respondents were asked to rate each pre-defined indicator on a Likert scale according to how important they felt each to be for electricity security in a low-carbon context (with 1 denoting minimal importance and 5 denoting critical importance).[2] Figure 1 shows the mean score and standard deviation for each indicator across all respondents. Figure 2 shows the individual responses, ordered according to the 6 constituencies in order to evaluate whether there is alignment between perspectives and constituencies (see section 4.2.1).

Figure 1 shows that the indicators within the 'availability' and 'reliability' dimensions were felt to be the most important, whereas most of the 'environmental sustainability' indicators received very low scores. Many respondents felt that the 'sustainability' and 'affordability' dimensions should be thought of as *separate* to security, whereas many were in agreement that the more traditional security dimensions of 'availability' and 'reliability' are integral to a conception of electricity security. However, within these dimensions, not all indicators were felt to be critical; notably, 'import dependence', which is often used as an indicator of energy security in the literature, was felt to be relatively unimportant.

The standard deviations shown in figure 1 illustrate that the areas of greatest contention were generally within the 'affordability' and 'sustainability' dimensions. In particular, fuel poverty and carbon emissions stand out as being particularly contentious. The reasons for this were discussed in section 4.1.1, where it was suggested that respondents appeared to be basing their responses on differing criteria for deciding what matters for energy security. The 'annual bills' and 'LCOE' indicators were also fairly contentious, illustrating general disagreement over whether 'affordability' should be viewed as part of a broad conceptualisation of energy security. Figures 1 and 2 also confirm that there is disagreement over the importance of some of the more traditional indicators of energy security such as imports and diversity.

4.2.1 Does 'where you stand depend on where you sit'?

Figure 2 illustrates there is no clearly discernible alignment between the constituency in which people work and the importance which they place on different indicators of electricity security. There is significant spread amongst responses for most of the indicators, no matter which constituency. The contentious indicators (i.e. those with high standard deviations) provide the clearest examples of this;

[2] Note: only 24 of the 25 participants returned quantitative answers

for all the most contentious indicators, individual responses within the same constituency tend to be very widely spread, and no clear patterns emerge.

The idea that perspectives are usually aligned with the organisation for which people work is often referred to as "where you stand depends on where you sit", or Miles' Law, after the Truman-era bureaucrat who coined the phrase (Encyclopædia Brittanica 2015). Influential work by Allison (1969; 1971) suggested that,

> "Where you stand depends on where you sit… Horizontally, the diverse demands upon each player shape his priorities, perceptions, and issues. For large classes of issues, the stance of a particular player can be predicted with high reliability from information concerning his seat" (1969: 711).

Several empirical studies corroborate Miles' law, with reference to a diverse range of fields (see for example Berman *et al* 1985; Vest *et al* 2010; Wilcher 1986). A large survey by Von Borgstede and Lundqvist (2006) found that acceptance of climate policy measures depends on a) organisational affiliation, and b) professional role; however, "Professional roles have an influence *over and above* organizational affiliation" (2006: 279, emphasis added). This suggests that we might expect more similarities between the views of two experts in different organisations but with the same role, than between two experts with different roles within the same organisation. This contention is difficult to test using the results from the interviews, because most interviewees hold similar roles within their respective organisations.

Bryan (2003) suggests that where you stand *does* depend on where you sit, but that it is necessary to conceptualise where people 'sit' as not just an expert's professional position but also the wider context, which could include people's existing 'baggage' such as previous or personal affiliations. The fact that the experts interviewed for this study did not conform to Miles' law simply suggests that there were other contextual factors – other aspects of 'where they were sitting' – which were having a more controlling influence over their decisions than the organisation for which they work. It may be because all the experts chosen for this study possess extensive experience and in-depth knowledge of energy issues, and therefore possess complex, nuanced and widely differing opinions; the qualitative data outlined in section 4.1 support this.

Fig. 1: Mean and standard deviation of scores across all respondents, ranked according to importance for electricity security in a low-carbon context on a Likert scale (1 = minimal importance; 5 = critical importance)

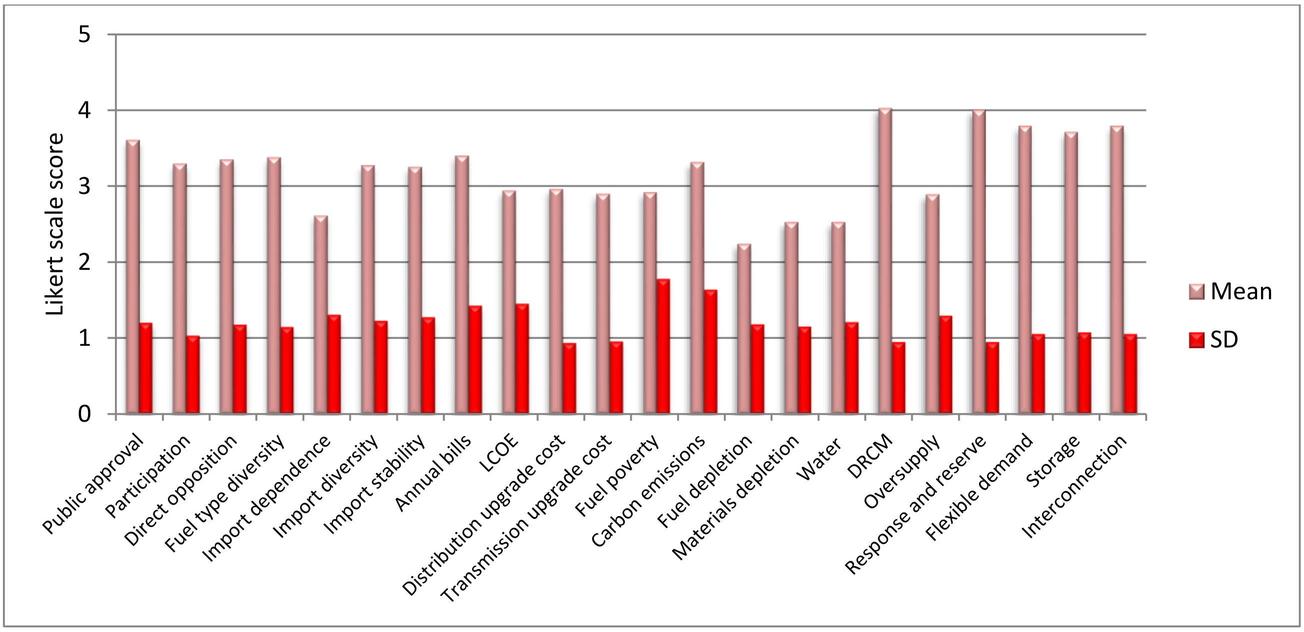
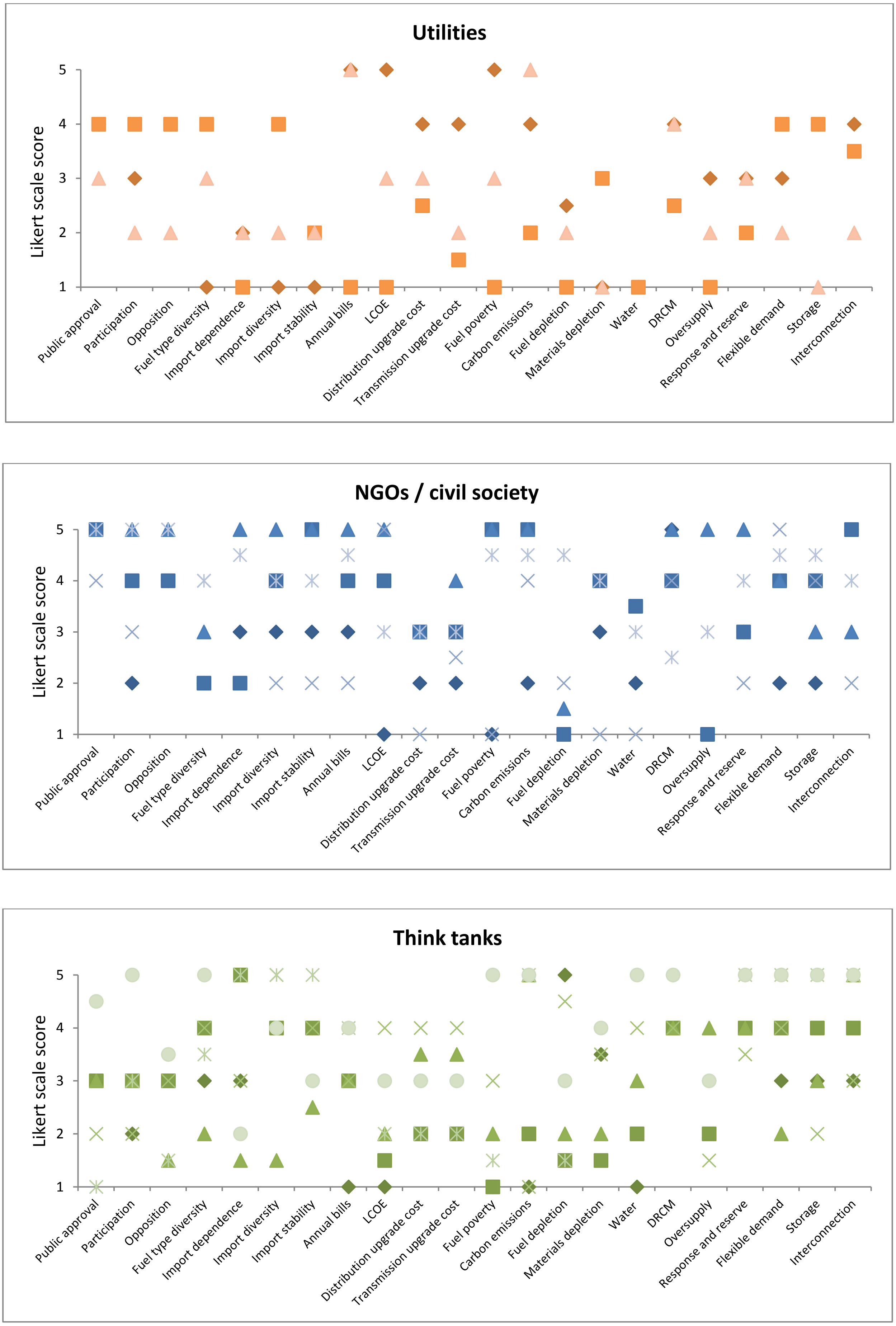
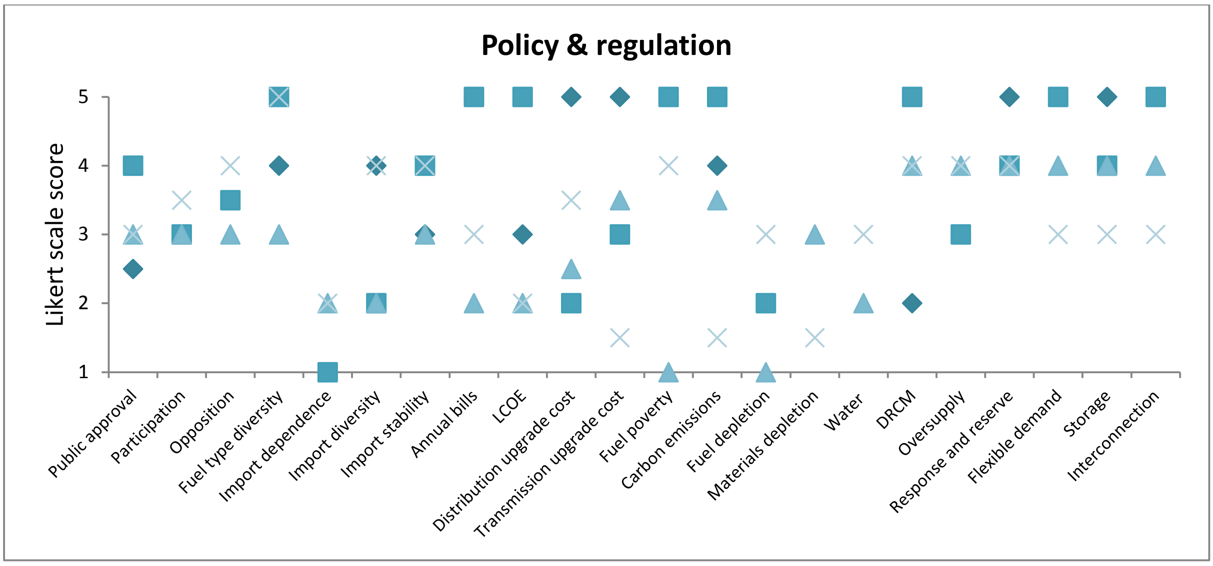
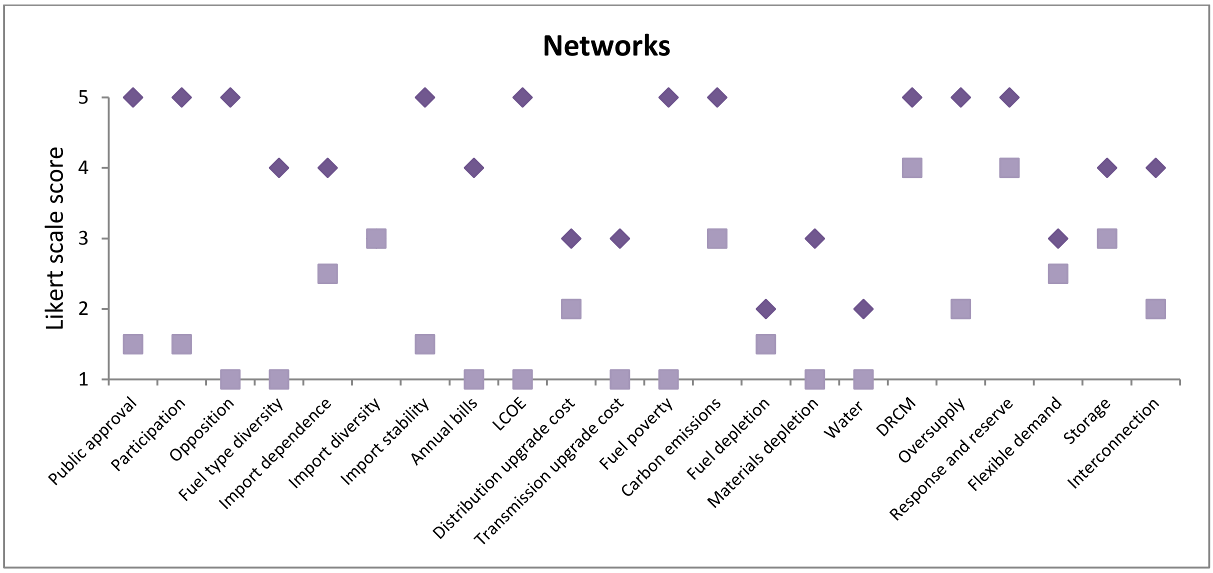
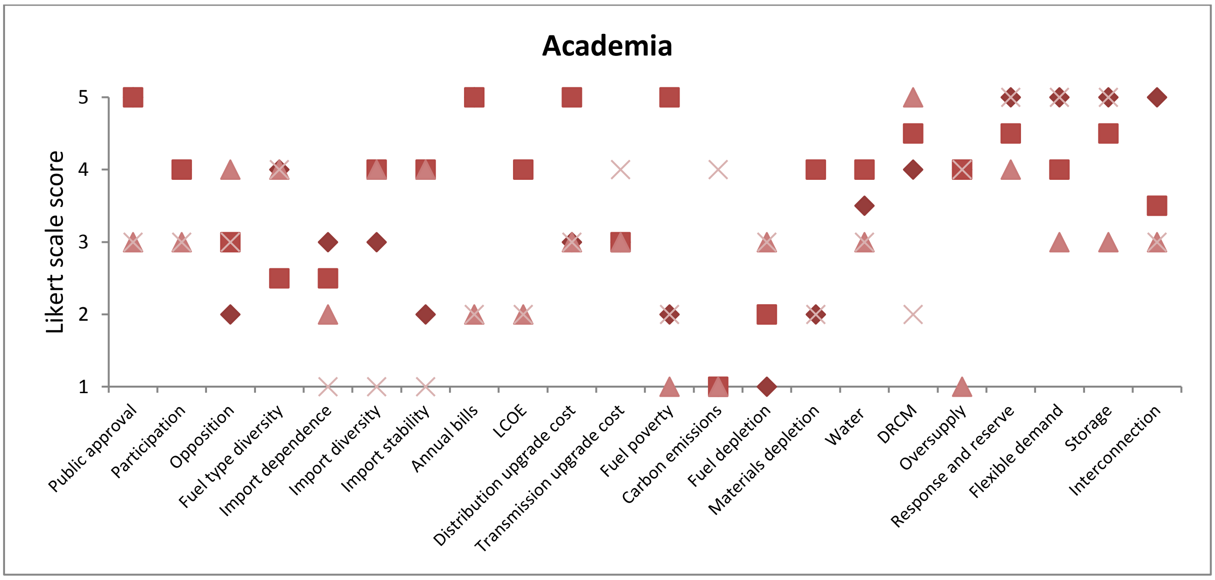


Fig. 2: Importance of each indicator to individual respondents, ordered by constituency




Policy & regulation
Likert scale score
5
4
3
2
1
Public approval
Participation
Opposition
Fuel type diversity
Import dependence
Import diversity
Import stability
Annual bills
LCOE
Distribution upgrade cost
Transmission upgrade cost
Fuel poverty
Carbon emissions
Fuel depletion
Materials depletion
Water
DRCM
Oversupply
Response and reserve
Flexible demand
Storage
Interconnection


Networks
Likert scale score
5
4
3
2
1
Public approval
Participation
Opposition
Fuel type diversity
Import dependence
Import diversity
Import stability
Annual bills
LCOE
Distribution upgrade cost
Transmission upgrade cost
Fuel poverty
Carbon emissions
Fuel depletion
Materials depletion
Water
DRCM
Oversupply
Response and reserve
Flexible demand
Storage
Interconnection


Academia
Likert scale score
5
4
3
2
1
Public approval
Participation
Opposition
Fuel type diversity
Import dependence
Import diversity
Import stability
Annual bills
LCOE
Distribution upgrade cost
Transmission upgrade cost
Fuel poverty
Carbon emissions
Fuel depletion
Materials depletion
Water
DRCM
Oversupply
Response and reserve
Flexible demand
Storage
Interconnection

5. Discussion

The results from the interviews have shown that there are significant differences between experts in what they feel is most important or material for electricity security. Roughly half of the respondents believed that a broad view of security should be taken encompassing aspects such as affordability and environmental sustainability, whilst roughly half felt that these broader aspects should be seen as separate objectives, trade-offs or complicating factors. There was considerable contention over some of the more 'traditional' indicators of energy security such as import dependence and diversity. This reinforces the recommendation of this paper that any assessment of energy security must attempt to 'open up' the discussion to take diverse perspectives into account.

The question of 'how to improve energy security' continues to resist a simple answer. It appears that some of the differences in responses may be explained by the different ways in which different experts judge what is important. Some respondents focused upon what they perceived to be current risks to the system or areas in which policy has an obligation to act, leading to a preference for indicators such as public acceptability and fuel poverty. Meanwhile, others focused on indicators which are simple and direct or more easily quantifiable, leading to a preference for indicators such as diversity and capacity margins. This is a preliminary finding which would benefit from further research. The results also demonstrated that experts' perspectives are not aligned with the constituency in which they work; this result suggests that individuals aren't being co-opted by the 'party line' of their various organisations, and suggests that measures targeted to appeal to specific types of organisation may be doomed to failure.

The results show that context is critical when experts are deciding which aspects of electricity security are important. For instance, the carbon reduction context is crucial: if the UK makes efforts to stay on-track to meet medium-term carbon budgets, security risks for the electricity system could be very different from a system in which decarbonisation has been sacrificed in favour of other objectives. Spatial context is also extremely important: for instance, a transmission upgrade in one location could be highly beneficial for security, but would be unnecessary and expensive if located poorly. Furthermore, the level of decentralisation is crucial: experiences in places such as Germany have shown that a decentralising system creates unique benefits and risks which are unprecedented in the UK's highly centralised system, and some indicators are far more important in the context of increased decentralisation. This strengthens the highly context-specific nature of energy security, and creates significant challenges for any attempts to create a generalisable framework which can be used in multiple contexts. The results therefore suggest that a 'dashboard' approach, in which a diverse set of indicators can be chosen according to their suitability for the particular context without the need for aggregation (Mitchell and Watson 2013), may be more suitable.

The respondents placed strong emphasis on the importance of securing adequate investment in infrastructure, including placing emphasis on the importance of maintaining political stability in order to ensure that investors have the confidence to build infrastructure. In order to generate the kind of political stability required to meet the challenges facing the UK electricity system, respondents discussed the need for long-term planning and a guiding 'vision' for the future, including improving political clarity on the level of commitment to the UK's medium-term decarbonisation targets. Ensuring this type of political stability may require a 'social contract' for changes which need to be made; for example, if the public don't feel that decarbonisation objectives are important, there could be backlash against measures which require additional spending or upheaval. These kinds of issues are clearly important for security, but are challenging to assess and even more challenging to quantify, which probably explains their lack of inclusion in security assessment frameworks thus far. The results from this study suggest that an important area for further research would be in working to include measures of economic and political feasibility in security assessments, including working on ways of assessing the current situation and likely future changes.

Nevertheless, despite the array of different perspectives and the challenges that this presents for assessments of energy security, there was commonality evident in the strong emphasis placed by respondents on measures of flexibility on both the supply-side and the demand-side (i.e. the ability to increase or decrease supply or demand in a timely manner in order to balance the system, in response to expected or unexpected perturbations in the supply/demand balance). In this way, experts can be seen to be placing emphasis on *responses to* insecurity, rather than focusing on minimising *causes of* insecurity; this is highly interesting, because the existing energy security literature tends to focus overwhelmingly on causes rather than responses (Jonsson *et al* 2013). This raises the possibility that previous attempts to assess the security of electricity systems may have been focusing on the wrong things, which could lead to a preference for systems which perform badly for flexibility but well for things like import dependence and fuel diversity. Flexibility on both the supply-side and the demand-side should be prioritised when assessing system security, and realising the potential benefits of improved flexibility should be a policy priority.

This paper interviewed energy experts using a pre-defined set of indicators, following methods used in other studies designed to elicit opinions on energy security (for example Blumer *et al* 2015; Sovacool *et al* 2012). The purpose of using pre-defined indicators was to attempt to tease out definitions of energy security from concrete underpinnings; if asked simply to define energy security, respondents may return answers based on common definitions which may bear little relation to some of the complex, nuanced and often very broad views identified in this paper. However, this methodology leaves the responses vulnerable to potential framing effects, in which some of the pre-defined indicators may have sparked interest from the respondents which would not have been apparent if the questions had been framed in a more open-ended manner. Therefore it would be beneficial for further research to elicit expert opinions using more open-ended questions, for instance by asking similar sets of experts to define energy security in their own words. Furthermore, it may be useful for further research to conduct a more detailed interrogation of the lack of alignment between experts' views and the constituency in which they work, for instance by carrying out a survey with a much larger sample size in order that statistical tests of correlation may be used. In doing this, it would also be useful to elicit opinions from individuals holding different roles within the same organisation, in order to explore in more detail the contention of Von Borgstede and Lundqvist (2006) that professional roles are more influential than organisational affiliation. Finally, it should be noted that this paper has interviewed UK energy experts to elicit opinions on what matters for electricity security in the UK context, because it has been shown that conceptions of energy security are highly correlated with national contexts. Therefore comparisons with other national contexts (for instance, by carrying out similar studies with energy experts from other industrialised nations) would potentially yield interesting comparative results, as would a cross-national study.

6. Conclusions

Energy security is a complex, multifaceted and polysemic topic, which despite the blossoming literature on conceptualisations continues to resist a commonly-accepted definition. Therefore this paper is an attempt to 'open up' this discussion in order to get a grasp on what aspects or dimensions of energy security are felt to be most important, with a focus on the security of the electricity system in the context of the imperative to reduce carbon emissions. Interviews were carried out with 25 experts from the UK energy sector, all of whom are involved with organisations which may have some impact or influence on energy policy. Participants were offered a list of indicators of electricity security drawn from the existing literature, and asked to discuss how important or material they felt these indicators are for assessing electricity security, with a particular focus on security in the context of a transition to a low-carbon electricity system.

The results from the interviews show that there is a real need to try to 'open up' the discussion around what energy security means to different people, instead of trying to close it down. There is a need to accept the existence of multiple perspectives and to at least attempt to take them into account when discussing energy security, instead of focusing down on a small number of simple quantifiable indicators or metrics. This paper has demonstrated that the challenges of attempting to create generalisable assessment frameworks are huge; instead of using aggregated indices, it is better to use a 'dashboard' approach which can incorporate a broad range of indicators in a more transparent and flexible way. There is no alignment between experts' perspectives and the constituency in which they work; therefore it is probably pointless attempting to create measures targeted to appeal to specific constituencies.

This paper has revealed an array of conceptualisations and a lack of any clear pattern determining experts' perspectives, as well as some competing worldviews which are potentially intractable. However, despite the challenges that this clearly creates for policy, certain measures were widely suggested as being sensible for improving energy security by a considerable number of participants from a range of organisations. Energy security policy should focus on measures which can *respond to* threats or insecurity, instead of focusing on reducing *causes of* insecurity; therefore a focus on flexibility on both the demand-side and the supply-side would be beneficial. There should also be increased focus on measures such as demand reduction which can bring about co-benefits in multiple dimensions. Finally, it is critical to ensure adequate investment in infrastructure, which requires political stability and long-term planning; these aspects are challenging to measure and therefore have received a lack of attention in energy security assessments in the past.

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Appendix A: Copy of briefing note sent to all stakeholders in advance

Expert Stakeholders: Briefing Note

"Assessing the future security of the UK electricity system in a low-carbon context"

Many thanks for agreeing to participate in this research; your views are highly valuable and greatly appreciated. This brief introductory document will set out the aims and background of the study.

During the interview, we will be discussing a framework for the assessment of the security of electricity systems in the context of a low-carbon transition. The indicators which make up this framework are presented overleaf. Please feel free to think about the indicators in advance of the interview; however, this isn't vital as there will be time for discussion in the interview.

Participants have been selected from diverse sectors including policy, academia, suppliers and civil society. Participants will be kept anonymous.
With permission, interviews will be recorded for ease of note-taking.

Background

In order to meet legislative targets for mitigating climate change, future energy systems will need to become secure, affordable and low-carbon – the so-called 'trilemma' of sustainable energy policy (Boston 2013). In the UK, the trilemma has received growing attention as energy security concerns rise up the political and public agenda, driven by declining indigenous fossil fuel reserves and increasing concerns over anthropogenic climate change (DECC 2012; MacKerron 2009). As part of a growing body of research into energy security and low-carbon energy transitions, this project focuses on the security of electricity systems in the UK in the context of a low-carbon transition.

Previous research has noted that 'energy security' means different things to different people (Chester 2010). This situation is unlikely to change; however, it creates challenges for energy security policy, because it makes it difficult to reach agreement on how best to maximise overall system security. This study will use the indicator framework overleaf as a starting point for a discussion about this diversity of views, including question such as:

- What are the most important dimensions of low-carbon electricity security?
- What metrics and indicators are most useful, and why?
- What impact do different timescales have on which dimensions are most relevant?
- Are there important dimensions and indicators missing from the framework?

During the interview, respondents will be asked to rate the indicators on a scale of 1 to 5, to reflect their importance as part of an overall assessment of the security of a low-carbon electricity system (with 5 as 'crucially important' and 1 as 'not important').

The indicator list is presented overleaf. Please feel free to think about how you would rate the indicators in advance; however, this isn't vital as we will be discussing them in the interview.

Indicators for assessing the security of low-carbon transition pathways for the UK electricity system

- Public approval
- Levels of public participation and engagement
- Likelihood of disruption due to direct opposition
- Diversity of fuel types in the energy mix
- Import dependence
- Import diversity (diversity of imports of both fuels and materials)
- Import stability (stability of major supply nations and supply routes to the UK)
- Annual electricity bills to consumers
- Cost of electricity generation (Levelised Cost)
- Cost of upgrades to the distribution networks
- Cost of upgrades to the transmission networks
- Impact on levels of fuel poverty
- Carbon emissions
- Depletion of major fuels (gas, coal etc)
- Depletion of secondary materials (metals, rare earth elements etc)
- Water consumption and water withdrawals
- De-rated capacity margins
- Oversupply / spare generation capacity
- Response and Reserve for Grid balancing
- Flexible demand
- Storage
- Interconnection

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