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SPECIAL FEATURE: ORIGINAL ARTICLE

The politics of making and un-making (sustainable) futures

Mapping diverse visions of energy transitions: co-producing sociotechnical imaginaries

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Abstract

The need to rapidly decarbonise energy systems is widely accepted, yet there is growing criticism of 'top–down', technocentric transition visions. Transitions are, such critics claim, unpredictable, contested, and comprise of multiple and competing perspectives. This paper opens up to diverse visions of energy transitions by studying a corpus of 12 visions produced across different 'institutional settings' of the state, business, science and technology, and civil society in the UK. We introduce a new analytical framework grounded in relational co-productionist perspectives in science and technology studies (STS) to comparatively analyse the similarities and differences of the visions in relation to four dimensions of sociotechnical transformation: meanings, knowings, doings, and organisings. Whilst research on energy transitions often focuses on dominant imaginaries within political cultures, regimes and centres of power, it is an explicit intention of this paper to also comparatively map the distributed, diverse and counter-hegemonic visions. The paper reveals that what is often presented as a primarily 'technical' transition is always normative in bringing forward particular forms of social and political order. Our analysis reveals important distinctions between more 'centred' and more decentred or 'alternative' imaginaries of the energy transition, differences which reveal the inherently political nature of energy futures. Visions which emerge from civil society settings are shown to be a key locus of diversity in sociotechnical imaginaries and tend to open up to alternative models of progress, social change, and the roles of publics. This emphasises the significant role played by the settings and the make-up of collective practices through which energy visions are co-produced. We suggest that mapping diverse visions to reveal their respective partialities, exclusions and sociopolitical dimensions in this way, can offer a more humble, reflexive, and responsible foundation for practices of future-making and sociotechnical transformations.

Keywords Visions · Sociotechnical imaginaries · Energy futures · Sustainability transitions · Co-production

Introduction

In recent years, energy has re-emerged as a pressing and salient political issue, with growing calls for a purposive 'energy transition' from a range of different actors including social movements (Hopkins 2008), governments (HM Government 2009) and a growing academic research community focused on accelerating sustainability transitions (Markard et al. 2012). Uncertainties relating to the future configuration of the energy system, of the appropriate mixture of technologies, of projected costs, of public 'acceptability' of certain technologies and of ways in which an energy transition might contribute towards meeting targets relating to climate change have led to calls for more science and research to address the perceived knowledge gaps (King et al. 2015). To date, a key approach to address these questions has been through the elaboration of energy scenarios and associated anticipatory techniques that aim to provide insights into different possible energy futures. These *futures for the present* are part of a broader trend to govern present energy systems and process of change using future-oriented methodologies (Söderholm et al. 2011).

In the case of the UK energy system, much of this work has been of a largely technical and quantitative basis, often

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drawing on computational models which, like other forms of model, exert epistemic authority, consequently, shaping policy interventions and the allocation of resources (Hulme 2013). Yet, despite the history of energy being deeply contested and political, many scenarios and visions neglect to explore the political dimensions of energy change. A similar critique has been levelled at the sustainability transition field where research is used to inform policy, but has not sufficiently accounted for issues of power, politics, and directionality (Shove and Walker 2007; Meadowcroft 2009). In other words, questions of 'whose vision counts?' are not properly considered, nor are considerations of which actors are included and excluded from decisions about—and who will bear the risks and benefits of—future sustainability transitions. To address this, it has been argued that more 'bottom–up' distributed approaches are needed that can better attend to diversities of actors, commitments, and alternative visions that are involved in systemic change (Stirling 2011).

This paper provides one such attempt at 'opening up' the diversities that surround different energy visions, in the sense of exposing the different framing conditions, assumptions and normativities within the processes of technological futures (Stirling 2008). It does this by taking a corpus of 12 different visions of an energy transition and comparatively analysing them in parallel to expose the commonalities and diversities in terms of their future-making practices and imagined futures. Adopting a *relational co-productionist* perspective (Chilvers and Longhurst 2015, 2016; Chilvers and Kearnes 2016), we build on the previous work that emphasises the importance of sociotechnical visions (Berkhout 2006) and sociotechnical imaginaries (Jasanoff and Kim 2009, 2015) in sociotechnical change. To date, such work has often focused on dominant or hegemonic imaginaries within political cultures, regimes and centres of power, whereas it is an explicit intention of this paper to also map some distributed, diverse, and counter-hegemonic visions (see also Smith and Tidwell 2016). We argue that attention to energy visions is critical for understanding the processes of sociotechnical transformations, not least because whether intentional or not all visions are performative in the sense that they shape and construct actors' present realities and the decisions that they consequently make (Michael 2000).

Our analysis shows how all sociotechnical visions are partial, situated and exclusionary in multiple ways (cf. Chilvers and Longhurst 2016). Energy visions are shown to be always co-produced in that what is often presented as a primarily 'technical' transition is also simultaneously normative in assuming and advocating desired states of social and political order (Jasanoff 2004). Furthermore, we show how competing visions have different implications for the role of society and different social actors—not least in terms of equity over the distribution of risks and benefits, and issues of inclusion and control (Leach et al. 2010; Macnaghten and Chilvers 2014). As such, attending to the diversity of visions, particularly those that are more radical or peripheral, is one way of opening up the politics of energy transitions and shedding light on the areas where contention exists. Thus, we conclude with a call for more reflexive approaches to energy futures' work, ones that attend to the societal dimensions, politics and potential diversities rather than closing down around a specific narrow approach to understand the future of energy systems.

The paper proceeds as follows: the next section reviews the relevant literature on sociotechnical visions whilst also briefly setting out the underlying theoretical approach. The third section outlines the methodology employed in the paper, followed by a description of the key findings of the comparative analysis. Building on this, a discussion draws out some key interpretive themes that emerged from the analysis. In conclusion, we reflect on the implications of our study for anticipatory energy futures and futures research more broadly.

Sociotechnical visions and imaginaries

Sociotechnical visions have been defined as "collectively held and communicable schemata that represent future objectives and express the means by which these objectives will be realised" (Berkhout 2006: 302). Berkhout suggests that visions tend to consist of issues (i.e. some kind of problematisation), technologies, and institutions/orders. Transition visions can, therefore, be scrutinised both for the rationale for the transition and in terms of a specific set of governance arrangements and technological configurations that are proposed. Visions can also invoke different geographical scales; for example, they may relate to specific countries (HM Government 2009); regions (Späth and Rohracher 2010) or cities (Hodson and Marvin 2009). The geographical imaginary is likely to be shaped by the interests or priorities of the organisation, individual or collective that has produced the vision.

The literature on energy futures commonly makes a distinction between descriptive and normative futures, where the former are more analytical and the latter are explicit about the kind of future that they want to produce (e.g. McDowall and Eames 2006; Söderholm et al. 2011). In contrast, this paper adopts a relational co-productionist perspective which suggests that even those visions which are seemingly descriptive or exploratory bring forward particular normativities in the form of imagined social, political and economic orders which extend beyond the exposition of future energy systems. The idea of a 'sociotechnical imaginary' captures the way in which technological visions can also produce imaginaries of social and political order. Jasanoff and Kim (2009: 120) introduce the concept of a

sociotechnical imaginary to describe "collectively imagined forms of social life and social order reflected in the design and fulfilment of nation-specific scientific and/or technological projects". Jasanoff and Kim (2009) contrast the different imaginaries that surround the nuclear power in South Korea and the United States, highlighting that, in each case, the technology was implicated in broader projects relating to progress and national identity. Jasanoff and Kim (2015) have subsequently refined and broadened their definition to acknowledge that imaginaries can be articulated by other organised groups including social movements and corporations. Thus, sociotechnical imaginaries are

> "collectively held and performed visions of desirable futures" (or of resistance against the undesirable), and they are also "animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology." Unlike mere ideas and fashions, sociotechnical imaginaries are collective, durable, and capable of being performed; yet, they are also temporally situated and culturally particular. Moreover, as captured by the adjective "sociotechnical," these imaginaries are at once products and instruments of the co-production of science, technology, and society in modernity (Jasanoff 2015, 19).

Within this paper, we, therefore, use the concept of sociotechnical imaginaries to refer to durable and collectively held visions which relate to particular technological projects, in this case a purposive energy transition. Underpinned by Jasanoff's (2004) idiom of co-production, the concept provides the impetus for an analysis of futures which recognises that technological visions are about more than just technologies, that they inevitably bring forward imagined social, political, and economic orders, whether or not this is their explicit intention.

Building on these insights, we have, in our previous work, developed a relational co-productionist approach for understanding diverse forms of participation in energy transitions (see Chilvers and Longhurst 2015, 2016; Chilvers and Kearnes 2016). This approach has taken sociomaterial collectives of public participation as its focus, conceptualising how the subjects (publics), objects (energy-related technologies and issues) and models (formats) of engagement are co-produced through the performance of participatory practices. Our comparative analysis of diverse forms of participation in energy transitions—ranging from government consultations, smart technology trials, grassroots community energy and activism—has shown how the particular sociomaterial settings and collective practices through which actors engage play a powerful role in shaping visions of 'the energy transition' that are contrasting, partial and often conflicting (Chilvers and Longhurst 2016). This paper takes this approach further by extending our analysis beyond collectives of public participation themselves to study the co-production of energy transition visions in actor collectives from settings across state, science and technology, business and civil society that are all engaged in the ongoing low-carbon energy transition.

We, therefore, argue that energy visions can themselves also be understood as collectives, assembled from a set of different sociomaterial elements and actors. Building on Jasanoff's (2004, 6) argument that co-production involves the "constant intertwining of the cognitive, material, social, and normative", we suggest that a vision is itself shaped by, co-produces and projects a range of meanings, knowings, doings, and modes of organising:

- *Meanings* normative framings of issues and problematisations, around which sociomaterial collectives cohere, their boundaries are drawn, and futures are imagined;
- *Knowings* epistemic orders, cognition and forms of knowledge which both shape, and are produced through, the performance of sociomaterial collectives;
- *Doings* forms of material commitment that are produced by sociomaterial collectives (through practices, technological change, and so on);
- *Organizings* the forms of governing and social organisation that are reflected in the way which particular sociomaterial collectives are configured.

The antecedents, framing conditions, and modes of orchestration and enrolment in any given vision can be traced, and a relational perspective helps draw attention to the ways in which different visions get assembled, the choices that get made, and the fact that they could be made otherwise. For example, energy visions vary in the extent to which they embrace a plurality of voices as inputs or as outputs. Some visions reflect the outcome of certain participatory processes, whereas others are less democratic in their construction. Similarly, whereas some might present a coherent narrative, others can be more internally diverse and even contradictory. Indeed, there is unlikely to be consensus surrounding any given vision when the wider context is considered, if only because of the uneven distribution of (perceived) winners and losers (Berkhout 2006).

From a relational perspective, we can begin to understand the situated formation of all visions, the extent to which they are partial and, yet, the productive effects that they have. Our approach conceives of visions as being potentially productive on all four dimensions of meanings, knowings, doings, and organisings. Across any given system, there are multiple forms of energy vision produced by actor collectives that are purposively engaged in the energy transition. These can be explicit visions—encoded in the form of documents or other media—or they can be implicit. An important implication

of this is that, whilst it is true that visions can be explicitly normative, even those that claim to be 'objective' are actually imbued with social, political, and ethical interests and exclusions.

Methodology

To explore the diverse visions that exist around the socio-technical imaginary of a UK energy transition, it was necessary to construct a corpus of relevant but diverse visions. Whilst other studies have conducted comparative reviews of energy futures, these often tend to be of one particular form of vision and from one particular setting [e.g. see Trutnevtye et al. (2016) review of UK energy scenarios]. A key purpose of our study was to attend to the diversity of visions, in terms of form, scope, and setting. A more experimental methodology was, thus, adopted to find a suitably broad sample of visions. A literature search was undertaken covering a 5-year period (2009–2014) following the publication of the UK Low-Carbon Transition Plan which was also included in the corpus. This rationale was based on the notion that the UK Low-Carbon Transition Plan reflected a specific high-profile articulation of a transition vision at time when the broader concept of 'transition' was gaining some kind of purchase (Bailey et al. 2010). We were, therefore, interested in exploring the diversity of other visions that emerged during this period that were linked in some way to the United Kingdom, either directly or implicitly as part of a wider 'global' vision of energy system transformation.

Each vision was an explicit expression of an energy future which was formalised, documented, published, and publicised, and, in some sense, intended to have a material effect in terms of shaping the future of the UK energy system. This encompasses those visions that are explicitly normative as well as those which are presented as descriptive, exploratory, or advisory. The sampling strategy was driven by the objective of maximising diversity across the four settings (state, civil society, business, and science and technology) where we would expect to find different framing conditions and different actors involved. Within each setting, additional criteria were applied to further enhance the diversity of the sample in relation to: (a) the geographical scale of the vision (local, regional, national, and global); and (b) the type of knowledge inputs (e.g. qualitative/quantitative). Using these criteria, three examples of a vision produced within each of the four settings were selected with an explicit intention of selecting a diverse corpus. In brief, these 12 visions were the following (see Table 1 for further details of the visions selected for analysis):

State

- UK Government—UK Low-Carbon Transition Plan (UKTP)
- INTERREG Consortium—An Energy Vision for the North Sea Region (NSV)
- Electricity Networks Strategy Group—Our Electricity Transmission Network: a vision for 2020 (ENSG)

Business

- World Economic Forum—Energy Vision 2013 (WEF)
- EDF Energy—Energy Futures (EDF)
- Confederation of Business and Industry—The Colour of Growth: Maximising the potential of Green Business (CBI)

Science and Technology

- Transition Pathways Consortium—Transition Pathways to a UK Low Carbon Energy Future (TP)
- UK Energy Research Centre—Energy 2050 (UKERC)
- Deliberating Energy System Transformation in the UK (DEST)

Civil Society

- Centre for Alternative Technology—Zero-Carbon Britain (ZCB)
- Transition Town Totnes—Totnes Energy Descent Action Plan (TEDAP)
- Quaker Peace and Social Witness—Ending Fossil Fuel Dependency (QPSW)

Source documents relating to each of the visions were subjected to a qualitative textual analysis, which was structured around a set of pre-defined in vivo codes that were informed both by our relational co-productionist approach and cognate literature on visions, namely:

(i) meanings, issues, and framings of the energy transition;
(ii) proposals relating to (material) technologies;
(iii) proposed governance arrangements;
(iv) knowledge inputs; and
(v) roles of different actor groups, including civil society and publics.

Using these sensitising categories, a further iteration of analytic coding was undertaken which was attentive to both the diversities within the narratives (Markusson 2013) and the extent to which shared 'elements' could be discerned (Levidow and Papaioannou 2013). In the cases where there were multiple scenarios within one vision, the coding took account of them all, so the results reflect a composite of the multiple visions within that particular source document. This

Table 1 The corpus of energy transition visions

Vision Abbreviation	Author	Title	Year	Type of actor collective	Objective of vision	Geographic imaginary	Format of vision	Significant knowledge inputs	Reference
UKTP	HM Government	The UK Low Carbon Transition Plan	2009	Produced by civil servants and government ministers	To show how the UK goal of binding cuts in carbon dioxide emissions can be achieved	National	White paper	Not specified	HM Government (2009) The UK Low Carbon Transition Plan, (Norwich: The Stationary Office)
NSV	Energy Vision for the North Sea Region consortium	An Energy Vision for the North Sea Region	2013	Consortium of local authorities and some other organisations in receipt of EU Interreg funding	Aims to speed up the energy transition in the North Sea region.	Transnational region	Webpages	Experiential learning from projects	Interreg IVB North Sea Region programme (2013) An Energy Vision for the North Sea Region, [webpage no longer available]
ENSG	Electricity Network Strategy Group (ENSG)	Our Electricity Transmission Network: A vision for 2020	2012	High level forum of key stakeholders in the UK Electricity System	A vision of changes required to the electricity transmission network that incorporates changes to generation scenarios, technologies, policy developments, etc.	National	Report	Gone Green Scenarios NETS SQSS Network analysis modeling	Electricity Networks Strategy Group (2012) Transmission Network : A vision for 2020, available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48274/4263-ensgFull.pdf (last accessed 30/05/19)
WEF	World Economic Forum (WEF)	Energy Vision 2013: Energy Transitions past and future	2013	"An independent international organization committed to improving the state of the world by engaging business, political, academic and other leaders of society to shape global, regional and industry agendas"	It seeks to provide a context and framework for understanding the energy mix, how a transition might unfold, and the challenges and questions about the components of the energy mix, both today and tomorrow	International	Report	Historical statistics, Individual perspectives.	World Economic Forum (2013) Energy Vision 2013. Energy Transitions: Past and Future, available from: http://www.weforum.org/reports/energy-vision-2013-energy-transitions-past-and-future (last accessed 30/05/19)
EDF	EDF Energy	Energy Futures	2014	"EDF Energy is one of the UK's largest energy companies and its largest producer of low-carbon electricity. A wholly-owned subsidiary of the EDF Group, one of Europe's largest energy groups"	To set out EDFs view on the UK energy future.	National	Webpages	Not specified	EDF Energy (2014) Energy Future [webpage no longer available]
CBI	Confederation of Business and Industry (CBI)	The Colour of Growth: Maximising the potential of green busines	2012	"The CBI is the UK's premier business lobby organization providing a voice for employees at a national and international level"	To describe how the transition can be a driver of green growth and how that can be realized.	National	Report	CBI statistical data	Confederation of British Industry (2012) The Colour of Growth: Maximising the potential of green business, available from: http://www.gci.org.uk/Documents/energy_climatechangerpt_web_.pdf (last accessed 30/05/19)
TP	Transition Pathway Consortium (TP)	Transition Pathways for a UK Low Carbon Electricity Future	2013	Interdisciplinary consortium of nine UK universities developing whole system approach to the development of Transition Pathways for the UK electricity system looking ahead to 2050.	To describe a set of possible future electricity pathways for the UK	National	Academic papers	Qualitative workshops and quantitative modelling	Foxon, T. (2013) 'Transition Pathways for a UK low carbon electricity future', Energy Policy, 52, 10 - 24.
UKERC	UK Energy Research Centre (UKERC)	Energy 2050	2011	Major Research Council UK (RCUK) Energy research centre involving multiple partners and streams of activity. Emphasis on whole systems, engineering and physical sciences.	A scenario based approach to think through different possible energy future	National	Book	UK MARKEL – MED energy model	Skea, J.Ekins, p. Winskel, M. (Eds). (2011). Energy 2050: Making the Transition to a Secure Low Carbon Energy System. (London, Earthscan).
DEST	Butler *et al.*	Deliberating Energy System Transformation in the UK	2013	Social science academic research project which enrolled engaged publics into the collective.	To explore public acceptability and attitudes in relation to different aspects of a UK energy transition.	National	Report	Deliberative workshops with members of the public	Butler, C., Parkhill, K.A. and Pidgeon, N. (2013) Deliberating energy transitions in the UK – Transforming the UK Energy System: Public Values, Attitudes and Acceptability (UKERC: London)
ZCB	Centre for Alternative Technology (CAT)	Zero Carbon Britain	2013	"CAT is an education and visitor centre demonstrating practical solutions for sustainability"	To describe how Britain could be zero carbon by 2030 whilst relying on existing technologies	National	Report	Scenarios based on assumptions, rules and existing data. Academic literature	Centre for Alternative Technology (2013) Zero Carbon Britain: Rethinking the Future, (Machynlleth, Centre for Alternative Technology)
TEDAP	Transition Town Totnes (TTT)	Totnes Energy Descent Action Plan	2010	"Transition Town Totnes (TTT) is a dynamic, community-led and run charity that exists to strengthen the local economy, reduce the cost of living and build our resilience for a future with less cheap energy and a changing climate"	A guide to reducing dependence on fossil fuels and reducing our carbon footprints over the next 20 years	Municipality	Report	Public workshops and exhibitions. Backcasting. Zero Carbon Britain reports. Academic literature	Hodgson, J. and Hopkins, R. (2010) Transition in Action: Totnes and District 2030: An Energy Descent Plan, (Totnes, Transition Town Totnes).
QPSW	Quaker Peace and Social Witness (QPWS)	Ending fossil fuel dependency	2013	QPSW aims to support "Quakers in Britain to live out their faith in the world"	To argue that fossil fuel dependency, it's impacts on people and the Earth, and how a transition to a more sustainable and just energy economy is possible.	National	Report	Not specified	Quaker Peace and Social Witness (2013) Ending Fossil Fuel Dependency, available from: https://bit.ly/2QyBYw2 (last accessed 30/05/19)

interpretive exercise was primarily focused on the explicit presence or absence of different elements or concepts within each vision; for example, the inclusion of specific problems, technologies, or different modes of governance.

Mapping diversities of energy visions

Figure 1 represents the four dimensions co-produced in each vision: meanings, knowings, doings, and organizings. In each case, the visions were analysed to assess which specific, identifiable sociomaterial elements were present or absent. For example, climate change was an element which featured as a 'meaning' across all 12 visions. The shading of the four 'petals' also indicates whether or not that particular dimension of change is explicitly included within the vision. For example, some visions, such as the CBI *Colour of Growth* report, do not explicitly set out a technological vision. In this case, there is just a problematisation (the rationale for why an energy transition is needed) and a set of policy proposals to maximise the potential of green economic growth. At a very basic level, this mapping illustrates how different visions—all of which deal with significant aspects of the energy transition—can be diverse and varied in the co-productive dimensions and elements which they include and imagine.

Figure 1 shows that the most constrained vision (in terms of the total number of elements made explicit across the four dimensions) is that of the Quaker Peace and Social Witness project. This vision represents an argument for a more green and equitable energy system without specifying how it should be achieved. It, therefore, stops short of offering any kind of recommendation in terms of technological or social organisation of the system. The Electricity Strategy Network Group is also a 'narrow' vision, but in the sense that it is primarily a technical vision. It contains very little explicit statements on the rationale behind the vision, nor on the social dimensions.

At the other end of the spectrum are those visions that contain a broader range of elements. Not only do these contain some details in terms of a proposed sociotechnical configuration of the energy system, but, in some cases, they also provide new knowledge about the energy transition. This is, particularly, the case in the Science and Technology setting, where the purpose of the vision is often to provide new appraisals of the energy system and its possible trajectory. However, even these have their own partialities and absences. Each of the four dimensions that make up the visions analysed is now discussed in more depth.

Meanings: issues motivating the energy transition

By including 'meanings' as one of its four dimensions, our relational co-productionist approach highlights the significance of normativities in systemic change, decentring material technologies from their often-dominant role as the primary driver. Three broad but somewhat overlapping themes emerged from the data in relation to the issues or 'matters of concern' that are being articulated by the visions in our corpus, namely: environmental issues, energy-related, and economic. Climate change was the only issue that was invoked by all 12 visions as a rationale for an energy transition. For example, in the foreword of the UK Transition Plan (UKTP), Ed Miliband—then Secretary of State of Energy and Climate Change—argues that the "new predictions from the Met Office and other scientists, the most detailed yet, show that the impacts of climate change are not just an issue for other countries and future generations, but an urgent issue for Britain" (UKTP, unpaginated). Energy security and the affordability of energy for consumers are the other two issues which feature prominently across multiple settings, although notably neither of these issues features prominently in the civil society visions. Climate change, energy security, and affordability have been described as the energy 'trilemma'—a three-pronged rationale for the reconfiguration of energy systems (Foxon 2013). Table 2 shows that the civil society visions in our corpus do not reproduce the energy trilemma, and, instead, open up a broader range of issues.

In contrast to the narrative around energy security—which often relates to the need to secure adequate supplies of fossil fuels—the civil society visions articulate a more negative framing of fossil fuels based on notions of vulnerability, addiction, and dependence. For example, the Transition Town movement—which forms the context for the production of the Totnes EDAP vision—was launched on the basis that there is a need to develop more resilient localised economies due to an over reliance on fossil fuels and the likelihood of 'Peak Oil' which will lead to increasing energy costs and scarcity (Hopkins 2008). This problematisation, therefore, emphasises the need to reduce the necessity of fossil fuel usage, rather than secure adequate supplies. The civil society visions also open up a much broader range of problematisations relating to the environmental impacts of the fossil fuel regime [for example, incorporating issues of 'planetary boundaries' (ZCB) and biodiversity (TEDAP)]. The civil society visions also include 'other' issues which fall outside the dominant trilemma such as intergenerational equity and the political power of energy companies.

In terms of the overall framing conditions of the energy transition, the visions which originate from the business setting are neither as narrow as those based primarily around the energy trilemma nor as broad as those

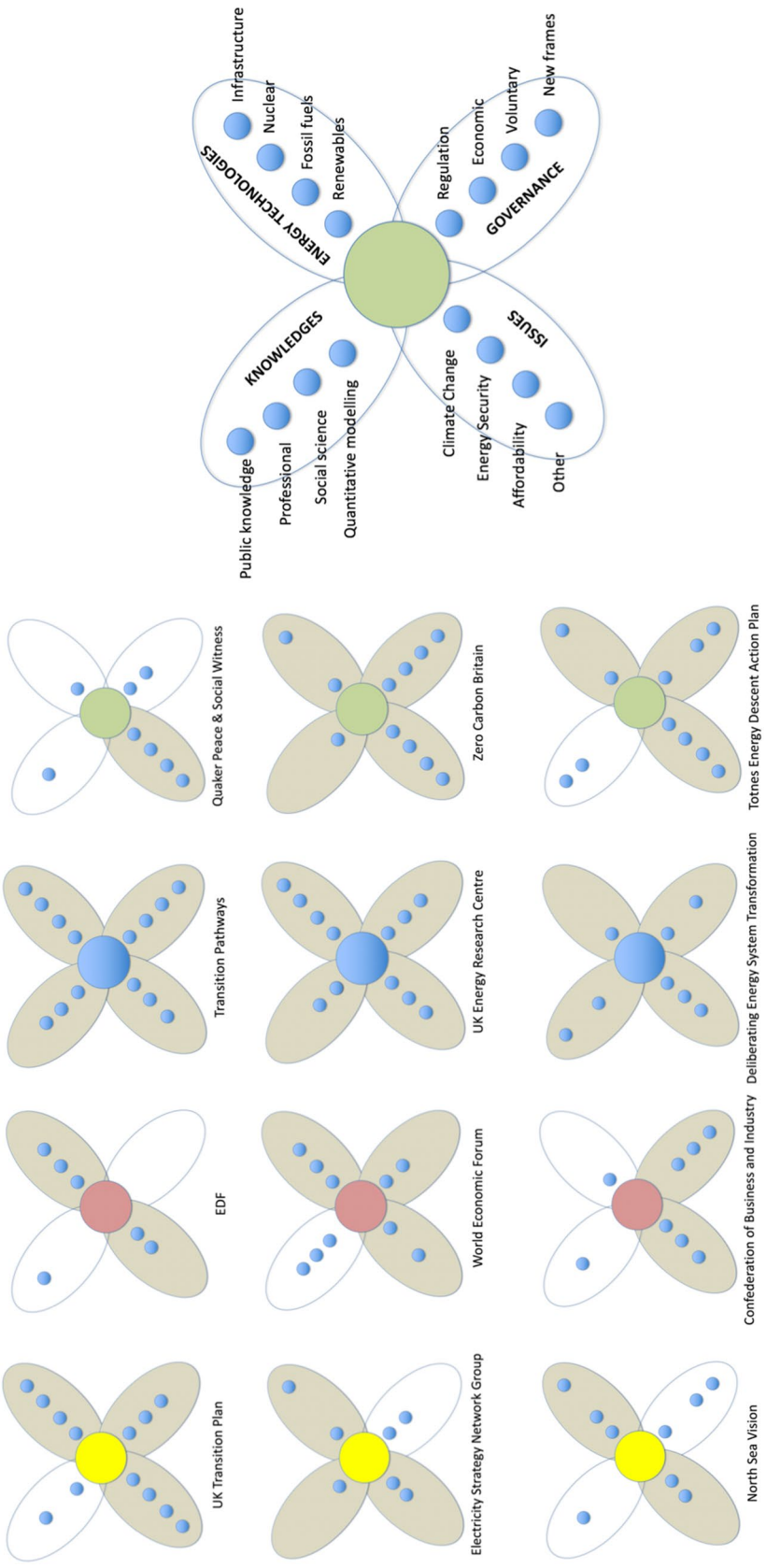

Fig. 1 Co-productive dimensions of energy visions

Table 2 Issues articulated by low-carbon visions

	UKTP	ENSG	NSV	WEF	CBI	EDF	UKERC	TP	DEST	ZCB	QPSW	EDAP
Climate change	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Other Environmental				✔						✔	✔	✔
Energy security	✔	✔	✔		✔	✔	✔	✔	✔			
Fossil Fuel dependence			✔							✔	✔	✔
Energy affordability	✔			✔	✔		✔	✔	✔		✔	
To support economic growth	✔			✔	✔							
To support degrowth										✔	✔	✔
Other										✔	✔	✔

Table 3 Material technologies proposed by competing low-carbon visions

	UKTP	ENSG	NSV	WEF	CBI	EDF	UKERC	TP	DEST	ZCB	QPSW	EDAP
Renewables	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Fossil fuels	✔		✔	✔		✔	✔	✔				
Nuclear	✔			✔		✔	✔	✔				
Infrastructure	✔	✔	✔				✔	✔				✔
Smart technologies	✔	✔	✔	✔			✔			✔		
Transport	✔		✔	✔			✔			✔		
Heating	✔							✔		✔		
Other				✔			✔					

originating from the civil society. In these visions, perhaps not surprisingly, there is a focus on the economic rationale for an energy transition. For example, the WEF report focuses on the future energy demands from emerging economies and the need to address energy poverty on a global scale. The need for an energy transition to support economic growth is also an explicit rationale of the CBI vision. In contrast, the civil society visions provide an interesting and diametrically opposite rationale, arguing that the transformation of the energy system is necessary to transition *away* from a growth-based economy which is environmentally and socially harmful. Here, the energy transition is part of the process of a shift towards 'degrowth' or steady-state economy (e.g. see Jackson 2009).

Doings: material technologies

Table 3 shows the summary elements of technological change that were contained within the different visions.

All 12 visions in our corpus propose renewable energy generation technologies—with offshore wind the most commonly proposed technology—but there is a large variation in the types and ambitions of the vision for a transition into a more renewable-based electricity system. For example, the ZCB vision has the broadest range of different renewable technologies, but this reflects its function as an appraisal of the energy system that illustrates that a 100% renewable energy system is technologically feasible (see Table 4). In doing so, it proposes a broad repertoire of technologies. A clear division in the visions is between the civil society narratives—which exclude nuclear and fossil fuels from the future energy mix, due to the perceived political, economic, and environmental effects of these energy sources—and the remaining three settings which include them to a greater or lesser degree. Visions which include these energy sources within their vision tend to argue that they are necessary for systemic 'diversity' (WEF) or for system balancing and providing baseload supply due to the intermittency of renewable sources. To retain fossil fuels as part of the energy mix, whilst also reducing the carbon emissions of the future system, these visions also tend to incorporate Carbon Capture and Storage (CCS) within their proposed repertoire of energy technologies.

Some other important commonalities can be discerned across the wider corpus. First, narratives emerging from all four settings include some kind of smart technology as being important to the future energy system, although details vary about the exact kind of implementation, and what this might actually entail (cf. Hargreaves et al. 2015). This reflects the

Table 4 Specific renewable generation technologies contained within visions

	UKTP	ENSG	NSV	WEF	CBI	EDF	UKERC	TP	DEST	ZCB	QPSW	EDAP
Geothermal heat			✔							✔		
Biomass			✔				✔	✔		✔		✔
Hydrogen			✔	✔			✔	✔		✔		
Biofuels				✔			✔					✔
Marine							✔					
Solar PV			✔			✔	✔					✔
Onshore wind			✔			✔	✔	✔				✔
Biogas			✔									
tidal			✔									
Offshore wind			✔	✔		✔	✔	✔		✔		✔
Energy from waste and Biomass										✔		✔
Hydro						✔	✔					✔
Marnie renewables						✔						✔
Solar hot water												✔
Tidal lagoon												✔
Desert generated solar energy												✔
heat pumps												✔
GM Algae				✔								
Synthetic biogas										✔		
synthetic biofuels										✔		

ongoing integration of energy and communication technologies, leading to increasing numbers of visions of 'smartness' around energy production and consumption. Second, visions produced in three out of the four settings emphasise the importance of infrastructure within the energy transition. The attention given to different forms of infrastructure (or lack thereof) can be one indicator of the situatedness of the different energy visions. For example, the ESNG vision is very much focused around developments required to the UK electricity infrastructure, particularly in terms of incorporating greater levels of renewable generation in the north of the UK. The attention that the NSV—a consortium of coastal municipalities—gives to infrastructure relates to harbour the infrastructure to facilitate the growth and maintenance of offshore wind. All four settings also include visions which refer to changes in the transport system, but in the most part such engagements are limited and partial: the significance of inter-system connections between energy and transport are acknowledged but not fully explored within the details of the visions.

Organizings: governance arrangements

The governance arrangements proposed by each vision have been coded in our analysis according to three conventional categories of policy instruments: regulatory, economic, and voluntary (e.g. see Skea et al. 2011). In addition, one further category emerged from our inductive analysis of the data which we have labelled 'alternative frames'. This relates to two different framing-based interventions that were proposed. The first is the way in which the development of scenarios or collective visions was itself proposed as a tool to stimulate systemic change. The second is related to the potential role for new forms of measuring 'progress' beyond simply measuring gross domestic product (GDP) such as quantifying 'well-being' or 'happiness' (Layard 2005).

Table 5 illustrates the wide diversity of different points and mechanisms that are imagined as effective strategies for the governance of energy systems. Overall, the most prevalent categories are 'new regulation', 'carbon accounting and taxation', and 'stimulating low-carbon investment'. In terms of patterning across the different settings, Table 5

Table 5 Governance approaches for steering the energy transition

	UKTP	ENSG	NSV	WEF	CBI	EDF	UKERC	TP	DEST	ZCB	QPSW	EDAP
REGULATORY	✔	✔	✔	✔			✔	✔	✔	✔	✔	✔
New forms of regulation	✔			✔			✔	✔		✔	✔	✔
Carbon rationing										✔		✔
De/re-regulation of energy		✔	✔				✔					
More coherent policy			✔	✔								
ECONOMIC	✔	✔		✔	✔		✔	✔		✔	✔	
Carbon accounting and taxation	✔	✔		✔	✔		✔	✔		✔	✔	
Consumer incentives	✔				✔							
Stimulating low carbon investment	✔			✔	✔		✔			✔	✔	
Advocacy of market based solutions	✔			✔			✔	✔				
Energy pricing / charging		✔		✔						✔		
Funding research				✔			✔					
Green New Deal							✔			✔		
VOLUNTARY	✔	✔	✔		✔		✔	✔	✔	✔		✔
Voluntary action by citizens								✔		✔		✔
Competitions to engage public	✔											
New forms of partnership			✔				✔	✔	✔	✔		
Information and education	✔		✔		✔				✔			
ALTERNATIVE FRAMES			✔		✔			✔		✔		✔
Alternative metrics and measurements								✔		✔		✔
Further visioning of futures			✔		✔							✔

illustrates that, in general, all three main kinds of governance instrument are recommended across the four settings. However, the business setting visions generally tend to include less regulatory proposals and instead favour various forms of economic intervention. In contrast, all three civil society visions see regulation as a key tool for system steering. Science and Technology derived visions appear to have more faith in the role of voluntary action, particularly new forms of partnership than, perhaps, some of the other settings.

Carbon management emerges as a governance intervention across the 12 visions with several different kinds of carbon management techniques proposed across the whole corpus. However, one clear distinction can be discerned relating to the distributive mechanism. Two of the civil society visions propose ration-based systems such as Tradable Energy Quotas (TEQS, see Fawcett et al. 2007) and Contraction and Convergence (Meyer 2000). In contrast, the state and academic visions focused on the more established (market-based) mechanisms of carbon accounting, trading, and

Table 6 Knowledge inputs and outputs in the corpus of energy visions

	UKTP	ENSG	NSV	WEF	CBI	EDF	UKERC	TP	DEST	ZCB	QPSW	EDAP
KNOWLEDGE INPUTS												
Quantitative modelling	✔	✔		✔	✔		✔	✔		✔		
Social science / humanities				✔			✔	✔	✔	✔	✔	✔
Professional knowledge	✔		✔	✔	✔	✔		✔		✔		
Public knowledge									✔			✔
KNOWLEDGE OUTPUTS												
Quantitative modelling		✔					✔					
Social science / humanities							✔	✔	✔			
Professional knowledge		✔	✔	✔	✔					✔	✔	✔
Public knowledge												✔

budgeting: for example, the continuation and expansion of the existing EU Emissions Trading Scheme (EUETS). These reflect very different allocative logics which relate to broader philosophies about how resources should be managed.

Knowings: energy knowledges

Table 6 illustrates how different forms of knowledge are entangled in visions of the energy transition. First, where these are clearly defined, it shows the knowledge inputs which went into constructing the visions. Second, it shows the forms of knowledge that the visions produce. In some cases, but not all, energy visions are explicitly intended to produce novel knowledge about (aspects of) the energy transition, what Smith and Stirling (2007) call forms of 'appraisal'. This is most obvious in the Science and Technology setting where researchers are often explicitly and intentionally engaged in knowledge production processes around the energy system, often to inform the policy debate surrounding energy, as in the case of all three S&T visions contained within the corpus. However, other actors also produce knowledge with the intention of informing debate or influencing actors, such as the ZCB report which is intended to prove the feasibility of a zero-carbon system by 2030. Similarly, the ENSG vision is an appraisal of the technical challenges of a more electric, more renewable system and how this might be achieved. Different appraisals also apply different forms of valuation to the visions. For example, none of the civil society visions consider the economic costs of their own particular proposals, whereas economic factors often feature as a primary concern in many of the other documents.

Across the corpus as a whole, the largest category of knowledge input to the vision articulation process is 'professional' which encompasses a range of different forms of knowledge including the tacit, experiential learning, and professional non-academic forms of expertise. Modelling and statistical analyses also feature as recurrent forms of knowledge input and output. Reviewing across the knowledge inputs and outputs in this way also reveals some of the interconnections between different forms of energy knowledge. For example, the fact that models, such as MARKAL, have played a big role in energy knowledge production in the UK (Taylor et al. 2014) is reflected in the fact that this model featured within two of the three academic visions (UKERC and TP) and the UK government are long-term users of MARKAL, which is designed to provide least-cost optimisation across a range of different technologies. In contrast, in the civil society setting, the TEDAP drew on the ZCB report within its own vision. Another example would be the way that the ENSG report draws on a set of National Grid scenarios. Energy visions tend to be built on previous forms of knowledge and ways of knowing and, therefore, can be shaped by the ways in which these antecedents were produced. Perhaps, for this reason, public forms of knowledge are much less prevalent as inputs to the articulation of the 12 visions analysed in this paper, as is social science—with an important exception being the DEST study. Until fairly recently, these have generally not been the prevalent ways of 'knowing' the energy system.

Patterns of commonality and difference

This section has highlighted some of the key patterns of presence and absence across the corpus of 12 energy transition visions. Four core commonalities can be discerned which, perhaps, represent the shared elements of a broader energy transition vision. First, to a greater or lesser extent, all of the energy visions contain the implicit assumption that it is possible to manage an energy transition through possible interventions in different points in the system. However, the modes and methods of intervention are multiple, with a large degree of divergence over many of the points and processes of intervention. How the transition should be managed is very much open to question. Second, climate change is the one issue that is shared by all 12 visions as something that is motivating an energy transition. Beyond this, there is wide variation from narrower framings of the issues to much broader entanglements with other environmental and political concerns which argue that energy systems are inevitably entangled in political and economic issues. Third, all the visions propose some kind of shift towards a more renewable-based energy system. Where they vary is on the exact configuration of renewable technologies, and the role for other energy sources including fossil fuels, nuclear, and CCS. Finally, nearly all visions contain some kind of proposal for the management of carbon. Where they vary is in the exact way this should be managed, through market mechanisms (e.g. EUETS), taxes, or rationing approaches such as TEQs.

Some more significant points of divergence can also be identified across the corpus. First, there is a stark difference between the model of future societal progress contained within the visions, which are based either on the continuation of, or rejection of economic growth. Second, there are varying degrees of attention to the distributional costs and benefits of the transition. In some cases, there is recognition of issues pertaining to justice and equity, such as the role of energy in armed conflict and questions of intergenerational equity, whereas such concerns are absent from others. Finally, there is a distinction between more centralised and more distributed configurations, in relation to the technological preferences, the governance arrangements, and the forms of relevant knowledge. In the next section, we draw out some broader interpretive themes emerging from the analysis.

Co-producing sociotechnical imaginaries

The co-production(s) of energy transition visions

The analysis undertaken in section four provides some important insights into the co-productive dimensions of energy transition visions and their relationship to broader sociotechnical imaginaries. Reading across the corpus of visions provides contrasting examples of the way in which the imagined configurations of energy technologies go hand in hand with particular visions of future social relations and forms of social order. For example, the highly renewable focused vision of Zero-Carbon Britain brings with it assumptions about reconfigurations in patterns of travel, leisure, and consumption (e.g. in the form of changing diets and agricultural practices). Similarly, the Transition Towns EDAP recognises the way in which energy is distributed and entangled in many different aspects of everyday life and embraces the changing nature of everyday life as a positive aspect of the overall transition; for example, a shift towards more walking and cycling, self-provisioning of food, and livelihoods which are embedded within an imagined local economy.

The work of Timothy Mitchell (2011) is illuminating in showing the co-productive relationship between political orders and energy systems. Within the cases analysed, visions which advocate a high degree of centralised large-scale energy technologies tend to 'produce' implicitly centralised and technocratic sociopolitical orderings. For example, ENSG produces a vision whereby the reconfiguration of energy infrastructure is primarily a technical and expert led activity, where the public and other actors exist only to be consulted in relation to the proposals that have been developed. Conversely, visions of social ordering that seek to enhance equity and democratic control produce alternative technological configurations. For example, it is for this reason that visions, such as the QPSW vision, promote a transition to renewables because of the political and democratic implications. Whilst different technologies can produce different social orders through the ownership and regulatory structures with which they are implicated, there is still a certain degree of openness in relation to the configurations of governance instruments that exist in relation to a given technology. This can be seen in multiple different mechanisms in which solar technologies can be deployed from community-based ownership to corporate investment models (cf. Hess 2013).

The exploration of the issues that motivate energy transition visions suggests that that low-carbon energy transitions are not narrow single-issue controversies, but should be understood as broader political situations (Barry 2012) where there is an interlinkage of multiple issues. The significance which different actors attribute to different issues and the associated risks inevitably shapes their vision; for example, the risks of climate change or nuclear energy. These assessments, therefore, underpin particular logics and rationales that then shape particular technological and governance proposals that are then developed. For example, the deeper problematisation of fossil fuels found within the

Table 7 Shared elements of energy visions

	Shared elements of visions
State	• Energy security as an issue • Focus on infrastructure • Focus on cost / economics of transition
Business	• Transition needed for economic growth • Affordability as an issue • Governance through economic intervention (especially the 'market') rather than regulation) • Fossil fuels and nuclear as part of the energy mix
Science and Technology	• Fairly narrow framing of the issue around the energy trilemma • Mixed energy system proposed • Broad range of governance instruments proposed • Support for economic growth implicit - neither advocated or opposed • Produce explicit knowledge in order to inform decision making
Civil society	• Broader range of issues motivating energy vision, e.g. procedural and distributive justice • Negative framing of fossil fuels • Focus on regulation and the rationing of carbon emissions • Transition as process towards 'steady state' economy • Funding / cost of transition not a concern • Interest in alternative metrics and measurements of progress

civil society visions leads to a more comprehensive rejection as part of the technological 'solution' to the energy crisis. Likewise, a concern with the implications of broader issues like justice and equity inform different forms of intervention in the system, such as the rationing of carbon, rather than its allocation through forms of market mechanisms. Indeed, the prevalence of the latter is also an evidence of the way in which energy and economic systems are deeply entangled, e.g., through the way in which neoliberal governance logics have shaped the energy system.

Situatedness of energy visions

A second important theme when interpreting the multiple visions analysed is that they illustrate the way in which all visions of low-carbon transitions are situated and partial. The sociomaterial 'setting' in which different visions are produced is at least partly relevant in shaping the particular vision that emerges, but so are the wider entanglements with extant orders and arrangements. Whilst we have to be cautious about drawing too many conclusions from this relatively small sample, Table 7 highlights some differences between more dominant sociotechnical imaginaries that are produced in the state setting, and alternative imaginaries that are primarily articulated through the civil society visions.

Whilst there is some difference between the perspectives co-produced in each setting, to some extent all of the visions are shaped by the existing 'constitutional' arrangements (see Jasanoff 2011) insofar that they contain aspects of the currently dominant ways of knowing, doing and organising energy, along with the meanings and frames associated with them. As a general rule, one might expect the visions that are positioned closer to the centres of power and calculation in the UK energy system to more recognisably reproduce the dominant sociotechnical imaginaries associated with energy transition. Therefore, we see the Low-Carbon Transition Plan offers a technological fix (dependent on Carbon Capture and Storage), based on a narrower set of issues (the 'trilemma'), organised using market-based mechanisms with the wider objective of using the trilemma to support economic growth. In contrast, as a general rule, those visions that are more 'decentred' (Irwin and Horst 2016)—located further from the relational 'centre' of the system, such as some of those from civil society—often tend to be less structured by the extant constitutional arrangements. However, it should also be noted that this is not necessarily always the case in every dimension. A good example is the Zero-Carbon Britain's vision of a transition to 100% renewable energy, which—whilst being a somewhat radical vision of rapid decarbonisation—draws heavily on modelling and technical data. In this sense, it has been shaped by the dominant epistemologies that shape energy scenario work in the UK, which tend to focus around quantitative modelling and the technical performance of technologies. By adopting the dominant conventions of energy knowledge production, the ZCB report is, therefore, seeking to gain power and

Table 8 Contrasting dominant and alternative sociotechnical imaginaries of the energy transition

Element	Dominant imaginaries	Alternative imaginaries
Overall trajectory	'Techno-fix' - technologies such as CCS mean that 'normal' life can continue without much adjustment	'Power down': life with less energy means shifts in cultural and social organization.
Issues pertaining to the Energy Transition	Narrowly framed around the Trilemma of climate change, energy costs, and security.	Energy transition motivated by a broader set of ethical, equity-related and environmental issues
Underlying organizational logic	Market mechanisms	Voluntaristic and rationing based
Relation to economic trajectory	An energy transition is needed to support jobs, wealth creation and economic development	An energy transition is needed to shift towards a 'degrowth economy.

establish certain forms of credibility within the wider debate around the future of the energy transition.

Like the CAT report, the Transition Town Totnes Energy Descent Action Plan articulates a sociotechnical imaginary which varies from the dominant 'centred' one: one which proposes sociocultural change instead of techno-fix, opens up a broader set of issues including peak oil, equity, and broader sustainability issues, is organised around voluntaristic and rationing-based systems, and argues that the transition is required to shift society away from an unsustainable capitalist development.

Reflecting on the ways in which different energy visions are situated draws attention to how such settings influence the production of 'Science and Technology' (S&T) visions, and, indeed, their relations to other visions that are produced. One clear pattern that emerges from the data is that S&T visions tend to much closer dominant imaginaries than the peripheral or alternatives ones. A certain degree of similarity between the S&T visions and the state visions can be observed. For example, in relation to the categories in Table 8, the S&T-related visions tend to replicate the dominant sociotechnical imaginary of an energy transition, rather than those that represent an alternative perspective. This is significant, because it might be considered that academia has a certain degree of intellectual freedom. However, the way in which research is entangled within the wider energy assemblage, through networks of financial capital and conventions of credibility, acts to shape the types of knowledge that are produced (Evans 2005). Kevin Anderson (2015) has recently drawn attention to this form of co-production in relation to climate scenarios where, he argues, political pressure leads the scientists to underplay the significance of their science and rely on unproven negative emission technologies (such as Carbon Capture and Storage) to make their messages politically palatable. Notably, many of the S&T visions are also dependent on CCS to meet their projected carbon targets. Other visions are less structured by dominant sociotechnical imaginaries. The association between less structured space and more radical forms of innovation is a core element of niche innovation theory (Smith and Raven 2012). In sociocultural terms, this often means that radical innovation is associated with countercultural sites, spaces, and networks (Longhurst 2015); for example, the vision of the Dark Mountain (2010) social movement, which explicitly rejects the modernist techno-utopianism of 'mainstream' visions (Graugaard 2014). It is, therefore, in such sites and spaces where novel ideas and (social) innovations are, perhaps, more likely to emerge.

Constructions of energy publics

Turning to constructions of publics, it is also evident that there is a great deal of divergence in how the roles of publics and wider society in energy transitions are imagined. Across the 12 visions included in our analysis, four distinct imaginaries of publics and their roles in energy transitions were evident:

- *Passive consumers* Publics are imagined primarily in a passive role as consumers at the back end of the energy supply system.
- *Protected publics* Publics are imagined as in need of protection and support either as motivation for the transition or through it.
- *Consulted citizens* Institutions realise that there is a public that needs to be consulted and create the opportunities to do so.
- *Active publics* Publics are imagined as active agents who can contribute to, or resist, the transition.

Table 9 shows how these distinct conceptions of the public relate to the different settings in which the visions of energy transitions were produced.

Some basic patterning of the different constructions across the four settings can be observed. First, it is clear that the civil society visions tend to produce a positive view of the role of publics within the energy transition. These

Table 9 Constructions of the public in energy visions

	Passive - consumer	Protected - Publics	Consulted - citizens	Active - publics
UKTP	✔	✔		+ / -
NSV				
ENSG			✔	
WEF	✔	✔		-
EDF	✔			
CBI	✔			
TP	✔			+ / -
UKERC	✔			-
DEST				-
ZCB				+
EDAP				+
QPSW		✔		+

visions tend to envisage that the public can show a leadership role, as well as practically engage in the transition in a number of different ways; for example, as energy producers (prosumers) or as participants and supporters of community energy projects. A consistent theme of the alternative sociotechnical imaginaries of an energy transition is, therefore, an envisaged relationship between a decentralised energy system and increased and more diverse instances of public engagement in the energy system. As such, these optimistic perspectives do not imagine that the public might, in some way, resist or object to the energy transition. In contrast, the S&T located visions tend to recognise both positive and negative roles for the public: positive in the sense of consumers who engage with smart devices to assist with demand management and reduction, but negative in terms of the potential for resistance to specific technologies such as the localised controversies that can arise around onshore wind projects. In the latter case, an 'active' public is active in its resistance to certain visions of the energy transition (Walker et al. 2007). The state situated visions do not demonstrate a strong patterning to their imaginaries of the public. They are present, but generally in fairly narrow ways, depending on the particular origins of the vision. Similarly, the business setting visions are also narrow in their conception of publics, mostly constructing them as passive energy consumers rather than more active participants in the system.

Future(s) implications

Sociotechnical visions and imaginaries of alternative possible futures play powerful roles in shaping decisions and commitments in the present. In this paper, we have deliberately sought to open up to diversities that exist around completing the visions of an energy transition, with particular reference to the UK. Our relational co-productionist approach has provided a view into how multiple actor collectives across energy systems co-produce different visions of what an energy transition might entail and, in many cases, work actively to shape the system according to these visions. Placing these visions alongside each other and exploring them comparatively have allowed us to demonstrate the importance of taking energy visions as objects of study, the significance of the collective practices and settings in which futures get made, and the ways in which visions of energy transitions could be produced otherwise.

Importantly, our analysis has shown how situated visions relate to wider collectively held sociotechnical imaginaries associated with low-carbon energy transitions. In these respects, the paper has made three important contributions to the studies of future-making.

First, through building on relational co-productionist scholarship in STS, we have set out a new analytical framework for mapping the dimensions of sociotechnical visions, which emphasises the co-production of meanings (issues), knowings (cognition), doings (material commitments), and organisings (governance arrangements). While these dimensions have at times animated previous studies

of the co-production of technoscience and social order, our framework has allowed a comparative analysis and visual representation of the inclusion and exclusion of elements on each of these dimensions that make up energy visions. Our analysis has shown all four dimensions and elements therein, to be evident in the UK energy visions of varying forms. Importantly, our analysis has shown that in all 12 visions considered in our corpus—whether they are more descriptive or normative, open or closed, quantitative or qualitative, analytical or discursive, and so on—these four dimensions are always co-produced. The technical, material, and cognitive aspects of future energy visions are inherently intertwined with social, normative, and political orders. This suggests that all energy visions are political, even where they are constructed and presented in a technocratic or scientific way, and the future evolution of energy systems, is deeply political (Meadowcroft 2009; Mitchell 2011). Furthermore, our analysis reveals that all sociotechnical visions are comparatively partial, each containing exclusions and inclusions in relation to each other. We suggest that our approach to mapping and visualising diverse visions could be productively used in future research to sensitise those involved co-producing sociotechnical visions to the partialities and exclusions of their own visions, to consider alternative possible imaginaries, and to anticipate possible future tensions and points of controversy (for example, over alternative models of economic development and progress, more centralised or distributed modes of governing, and so on).

Second, our analysis has shown that the make-up of sociomaterial collective practices through which sociotechnical visions get made (including the actors which are included and excluded from their production), as well as the institutional, discursive, epistemic, and material settings in which they are co-produced, fundamentally matters to the imagined futures that are produced, circulate and express agency in the world. A crucial finding of our study is how visions co-produced within institutional settings of the state, business, and academic research while expressing divergences between themselves, often exhibited significant differences compared to visions in our analysis which originated from civil society settings. Sociotechnical visions orchestrated by state, business, and academic research settings were more closely associated with the dominant sociotechnical imaginary of the UK energy transition identified in our analysis, which emphasised large-scale technological change, narrowly defined issues of the energy trilemma (climate change, cost, and energy security), and incumbent neoliberal models of economic development and progress. This is in contrast to visions emerging form civil society settings, which were more closely associated with alternative sociotechnical imaginaries of UK energy transitions, varyingly placing more emphasis on social and cultural change, a broader set of ethical, equity-related and environmental issues, and alternative models of progress including the models of 'degrowth'. Our analysis suggests that sociotechnical visions produced beyond formal institutions in civil society settings are shown to be more diverse and create distributed spaces where counter-hegemonic sociotechnical imaginaries can be (re)produced and circulate across space and time.

Yet, whilst we found that certain 'dominant' collectively held imaginaries of the transition tend to be (re)produced in more formalised institutional settings, it would be erroneous to assume that such patterning is inevitable. Our findings also warn against the simplistic reification of differences between visions produced in formal institutional settings and those emerging in more informal spaces in civil society and beyond. Our analysis provides evidence of opening up and closing down (Stirling 2008) in relation to meanings, knowings, doings, and organisings occurring in visions emerging across all four settings and forms of collective practice in our corpus. It just so happens that visions associated with formal institutions of science, business, and the state in our analysis were more closely relationally connected with—being shaped by and shaping—the dominant sociotechnical imaginary of the UK energy transition associated with the central stabilities of the UK energy system as constitution (see Chilvers et al. 2018) and a UK political culture with a traditional preference for high evidential standards and sound scientific knowledge in relation to policy making (Jasanoff 2005). In most cases, the importance of the settings and collective practices through which sociotechnical visions are co-produced was more significant than the individual actors involved. Even where deliberate attempts were made to democratise the co-production of energy future visions, we see the settings and collective practices through which actors (e.g., various publics) are engaged playing a fundamental role in shaping and formatting the visions produced. For example, moves to open up government and scientific research energy visions (RTP and UKERC) to public inputs did not prevent the framing, conditioning, and formatting of these processes around imperatives of the dominant sociotechnical imaginary associated with incumbent institutions, where assumptions about models of economic development and progress were held to a large extent constant.

Finally, a further important implication of our study is that in both interpretive analyses of, and practical interventions in, future-making, it is fundamentally important to open up to the diverse settings and collective practices through which futures are co-produced (cf. Chilvers and Longhurst 2016). For example, the exclusion of diverse civil society settings and spaces, and associated actors, from (studies of) initiatives to develop visions, scenarios and imaginaries of energy transitions would dramatically close down imagined futures, foreclosing more radical, distributed, and speculative alternatives. This should be guarded against in future research and anticipatory practices in the

fields of energy, climate change, and beyond. Furthermore, it is important that emerging studies of sociotechnical imaginaries do not only focus on dominant, hegemonic, and central imaginaries that have and continue to shape our collective futures (Jasanoff and Kim 2015), but, at the same time, pay due attention to the counter-hegemonic imaginaries that are more marginal, distributed, and decentred. This presents a key challenge, both to our current analysis and future studies, as such visions and imaginaries are much less readily codified, documented, and publicised, in future, past, and present. We suggest that comparative analyses employing frameworks such as those developed in this paper have a crucial role to play here, not only in comparing between imaginaries associated with nation states but also between sociotechnical imaginaries co-produced through more localised and transnational spaces of future-making in sustainability transitions, and the interplays between them.

In a more practical sense, opening up to diverse spaces of future-making implies that those who are responsible for the production of visions should acknowledge the partiality of all sociotechnical visions, explicitly recognising that exclusions are inevitable and being transparent about the assumptions and partialities that are contained therein. This implies a different approach to practices of visioning around energy transitions, one which complements the dominant scientific future-making practices of modelling and prediction with alternative methods which map extant diversities (as we have attempted in this paper) and, thus, provide a more humble, reflexive and responsible foundation for practices of future-making and sociotechnical transformation.

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