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MAPPING DIVERSE VISIONS OF UK ENERGY TRANSITIONS: CO-PRODUCING SOCIO-TECHNICAL IMAGINARIES

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ABSTRACT

The need to rapidly decarbonise the energy systems which underpin modern societies is widely accepted, yet there is also 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 UK energy transitions by studying a corpus of twelve visions produced across different 'settings' of the state, market, science & technology, and civil society. Adopting a relational co-productionist perspective (Chilvers and Longhurst, 2015) the paper analyses similarities and differences of the visions in relation to four dimensions of socio-technical change: meanings, knowings, doings and organisings. Whilst research on energy transitions often focuses on dominant imaginaries within political cultures and centres of power, it is an explicit intention of this paper to also comparatively map distributed and diverse 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 highlights a distinction between more 'centred' and more 'alternative' imaginaries of the energy transition. The centred imaginary - associated with the state, business, and science and technology settings - envisages a techno-fix, market driven transition, motivated by the energy trilemma, and contributing to ongoing economic growth. In contrast, an alternative vision, originating primarily in civil society, is one that is motivated by a broader set of issues (e.g. equity, biodiversity), is facilitated by voluntaristic mechanisms, involves broader social and cultural change, and is economically oriented towards 'degrowth'. Civil society visions are therefore a key locus of diversity across the four dimensions of socio-technical change and also tend to imagine more active and diverse roles for the public than visions originating from other settings. We conclude with a call for more reflexive approaches to energy futures work, that can open up and account for the societal dimensions, politics and potential diversities rather than closing down around narrow top-down approaches to governing energy transitions.

Key words: Energy visions, sustainability transitions, transition pathways, governance.

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PARTICIPATION AND ENGAGEMENT
SCIENCE, POLICY AND GOVERNANCE
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1. 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 quarters (Hopkins, 2008; AGECC, 2010). Uncertainties relating to the future configuration of the 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). A key approach in terms of addressing these questions has been through the elaboration of energy scenarios and associated anticipatory techniques that try to provide insights into different possible energy futures. These approaches are part of a broader trend to govern the present by using future orientated 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 drawing on established and credible energy models (Skea *et al.*, 2011). The notion of a managed energy transition has also gained increasing currency, popularized by social movements (Hopkins, 2008), government policies (HM Government, 2009) and the growing academic research field of sustainability transitions (Markard *et al.*, 2012). This paper itself is the product of an academic research consortium – *Realising Transition Pathways* (RTP) – funded by the Engineering and Physical Sciences Research Council (EPSRC) that is situated in the academic sustainability transitions field and with a remit to explore future UK energy pathways.

The consortium produced three 'Transition Pathways' which combine a qualitative future orientated narrative with quantitative modelling to project future electricity supply and demand up to 2050, based on three different *governance logics* (Foxon, 2013). These logics are intended to reflect the way in which different actors employ different rationales for the organisation of the system and attempt to enrol others to adopt their particular perspective. So *Market Rules* reflects a market based pathway with private energy companies taking a significant role. Central Control is a state led pathway, whereas *Thousand Flowers* is a pathway where civil society actors play a significant role in the system. Like other work in the field of sustainability transitions, the Transition Pathways project takes an approach which conceptualizes energy systems as socio-technical, recognising the significance of the socio-cultural dimensions of systems in addition to the more obvious material and technological elements. One particular critique that has been levelled at the sustainability transitions field, and particularly those approaches which seek to intervene in the system or forecast future pathways, is that they do not fully account for issues of power, politics and directionality within their work (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 the deliberations and implementation of transition related processes. To address this it has been argued that we need a more 'bottom up' distributed approach that can account for the diversity of actors, commitments and perspectives that are involved in systemic change (Stirling, 2011).

This paper provides one such attempt at 'opening up' the diversities that surround different energy visions. It does this by taking a corpus of 12 different visions of an energy transition and analyzing them in parallel to expose the commonalities and diversities. Adopting a *relational co-productionist* perspective (Chilvers and Longhurst, 2015) we build on previous work that emphasizes the importance of visions and socio-technical imaginaries (Berkhout, 2006; Jasanoff and Kim 2009) in socio-technical change. We note how this work often focuses on dominant imaginaries within political cultures and centres of power, whereas it is an explicit intention of this paper to also map distributed and diverse visions - including their relations with constitutional stabilities. We would argue that attention to energy visions is critical for understanding processes of sociotechnical change, not least because whether intentional or not, all visions are *performative* in the sense that they shape and construct actors' realities and the decisions that they consequently make.

As part of this exercise we have deliberately included the three Transition Pathway narratives from the RTP project as one of the twelve selected visions. In doing we are able to locate it reflexively within in a broader range of sites, settings and framing conditions where future trajectories of the energy system are being imagined. Our work also has broader implications for energy related futures research:

- First, by illustrating the *partiality of all visions*. The complexity of energy system change means that comprehensiveness is impossible. All visions are partial, situated and exclusionary in multiple ways.
- Second, the paper illustrates that *energy visions are always co-produced*. Not only are they shaped by their relations to the extant socio-political orders, but we show how what is often presented as a primarily 'technical' transition is always a normative in bringing forward particular forms of social and political order.
- Third, *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. These need to be actively reflected upon not ignored or dismissed. Thus we conclude with a call for more reflexive approaches to energy futures work, one that appreciates and celebrates the societal dimensions, politics and potential diversities rather than closing down around a specific narrow approach to understanding the future of the energy system.

The paper proceeds as follows. Section two reviews the relevant literature on socio-technical visions whilst also briefly setting out the underlying theoretical approach. Part three outlines the methodology employed in the paper, whilst section four describes the key findings of the comparative analysis. Building on this, section five provides further interpretive analysis of the key themes that emerged from the data. Finally, section six provides some reflections on the implications of the analysis, for the Realising Transition Pathways project, and more broadly for anticipatory energy research.

2. VISIONS OF ENERGY TRANSITIONS

In 1977 Denis Hayes presented one of the earliest visions of how energy transition might be steered at the societal level. *Rays of Hope* was prescient in its recognition of the growing significance of climate change and fossil fuel depletion as political issues. A similar contemporary vision was produced by the German *Institute for Applied Ecology* in 1980 which introduced the term *Energiewende* - the German phrase for an energy transition. Both these early articulations of energy visions eschewed nuclear technologies in favour of renewables and energy efficiency and prefigure many of the debates around energy transitions that continue today. Transition theories that seek to explain socio-technical change have emphasized the significance of such visions. In the context of governance experiments in "Transition Management", guiding visions play an important role in coordinating across multiple stakeholders and participants (Loorbach, 2010). Those approaches which focus more explicitly on the scaling up of 'niche' technologies – such as Strategic Niche Management (SNM) and the Multi-Level Perspective (MLP) - have also drawn on work relating to sociology of expectations and the way in which positive visions articulated with reference to particular technologies can be important in processes of network building and the enrollment of resources and support (Raven, 2012; Verbong and Geels, 2007).

Frans Berkhout (2006) has provided some of the most detailed reflections on the role of visions in socio-technical change, including offering a definition: that they are

> "collectively-held and communicable schemata that represent future objectives and express the means by which these objectives will be realised."

He goes on to outline five different roles that visions can play in processes of socio-technical change:

1. **Mapping a 'possibility space':** Visions identify a realm of plausible alternatives for conceiving of socio-technical functions and for the means of providing for them.
2. **A heuristic device:** Visions act as problem-defining frames by pointing to the technical, institutional and behavioural problems that need to be resolved in order for a particular vision to be realised.
3. **A stable frame for target-setting and monitoring progress:** Visions stabilise technical and other innovative activity by serving as a common reference point for actors collaborating on its realisation.

4. **Metaphors for building actor-networks:** Visions specify relevant actors (including and excluding those who may play a role in realising a vision), acting as symbols, narratives and moralities that bind together communities of interest and of practice.
5. **A narrative for bringing together and focusing resources:** (capital, knowledge, networks, skills etc.): Visions become emblems that are employed in the marshalling of resources from outside a core membership of actors already committed to a specific vision.

Berkhout (2006) suggests that visions tend to consist of issues (i.e. some kind of problematisation), technologies and institutions / orders. Transition narratives can therefore be scrutinized both for the rationale for the transition and for the anticipated contours of socio-technical change that are proposed in order to address the problem, in terms of a specific set of governance arrangements and technological configurations.. 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). Often the geographical imaginary is likely to be a function of the interests or priorities of the organization or individual that has produced the vision. Another important dimension of diversity is the cultural and material form that the vision takes. Whilst analyses often tend to focus on written texts as the primary medium in which visions are encoded, socio-technical futures might also be articulated in the form of film (especially documentary, but also fiction), novels, music, performance art, even video games. Berkhout (2006) also observes that the breadth of visions is variable: they can be either narrow and technical or broad and detailed depictions of possible futures.

The way in which socio-technical visions play a role in creating broader narratives of change is captured by Jasanoff and Kim's (2009) idea of a socio-technical imaginary. This reflects the

> "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 nuclear power in Korea and the United States highlighting that in each case the technology was implicated in broader projects relating to progress and national identity. In the context of this paper it is possible to conceive of the low carbon transition as a state led technological project that produces a wider set of imaginaries relating to the role of technologies, the roles of social actors and the relations amongst the various elements. The idea of a socio-technical imaginary captures the way in which (state led) technological projects produce not only visions that directly relate to the technology itself, but also wider visions of social and political order.

Jasanoff's (2004) idiom of co-production provides the impetus for an analysis of visions that recognises that they extend beyond the immediate technological configuration itself, that technological visions are about more than just technologies, they entangled in wider social and political narratives. So too are the technologies themselves, forever implicated in both stabilized configurations (such as infrastructure) and subject to competition and the possibility of emergent change. Relational perspectives on transitions tend to focus on the way in which these relations unfold, on the interdependencies and disjunctions between different forms of socio-technical arrangement (Chilvers and Longhurst, 2015). These approaches eschew the narrower, level based analysis of the multi-level perspective to focus on the way in which the ecological entanglements of different collectives across the system produce the overall trajectory of change.

Our own relational approach conceives of an energy 'system' being constituted by a multitude of socio-technical arrangement, each itself consisting of various human, non-human, material and discursive elements (Chilvers and Longhurst, 2015). Each of these elements can also be considered an arrangement in the same way. We call the most basic forms of these arrangements collectives, these are the socio-material arrangements which take many recognizable forms (technologies, organisations, infrastructures, actors, laws, documents) and which collectively constitute the 'system-as-assemblage'. Spaces of coherence are more complex networks of actors and elements which are more or less stabilized such as controversies, fields of knowledge, technological fields or institutional structures. This approach emphasizes the way in which all arrangements are entangled in productive relations with other arrangements, both shaping and being shaped by the context in which they exist. While these relations could be categorized in many ways, our approach foregrounds four broad dimensions:

- *Meanings* – normative framings of issues, problematisations, imaginaries around which socio-material collectives cohere and their boundaries are drawn;
- *Knowings* – epistemic orders, cognition and forms of knowledge with both shape, and are produced through, the performance of socio-material collectives;
- *Doings* – forms of material commitment that are produced by socio-material collectives (through practices, technological change, and so on) and are in turn shaped by the materiality of exiting collective complexity;
- *Organizings* – the forms of governing and social organization that are reflected in the way particular socio-material collectives are configured.

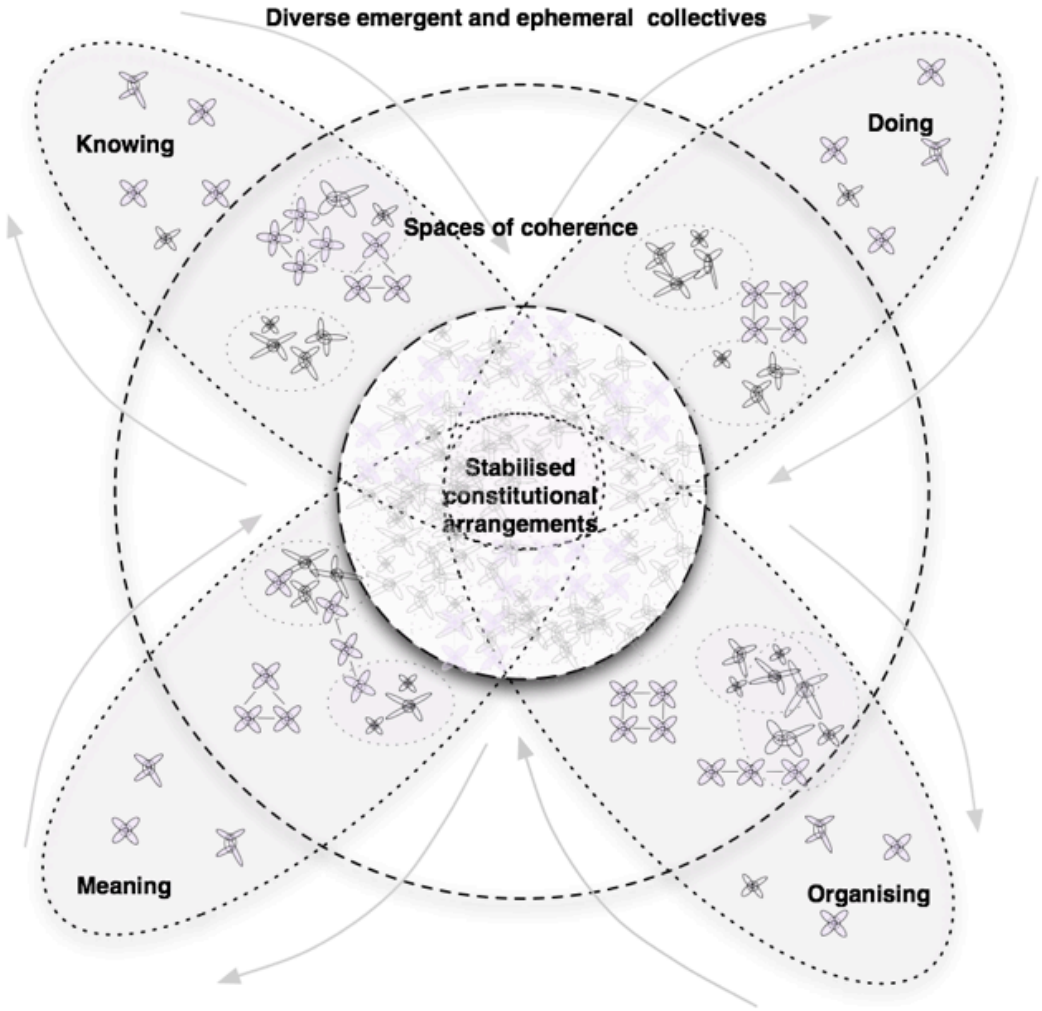


Figure 1: A conceptual representation of a system-as-assemblage, illustrating the relations between more-or-less stabilized 'centred' constitutional arrangements, spaces of coherence, and diverse/ emergent 'decentred' collectives.

We refer to the stabilities and durabilities of a system-as-assemblage as being constitutional in nature. This emphasises the ways in which relations between civil society, science and the state in particular democratic settings are held together in constitutional configurations – made up of established institutions, regulations, laws, political economic arrangements, sociomaterial infrastructures, policy cultures, and so on. In the context of our relational co-productionist approach the idea of a sociotechnical constitution is helpful in understanding complexes of arrangements that are continually performing stabilities within a system-as-assemblage (Chilvers and Longhurst, 2015). In this respect we draw inspiration from Jasanoff's use of Ackerman's (1983) notion of situated, place-based and historically grounded 'constitutional moments' to understand the way in which periods of relative stability can be punctuated by moments of reconfiguration. Constitutional moments are "brief periods in which, through the unending contestation over democracy, basic rules of political practice are rewritten, whether explicitly or implicitly, thus fundamentally altering the relations between citizens, [science] and the state" (Jasanoff, 2011: p.623). The notion of constitutional arrangements is useful in drawing attention to the way in which relations between actors from science, civil society and the state are held together by relatively stabilized configurations of laws, regulations and political cultures.

Our approach conceives of all arrangements as being potentially productive on all four dimensions. Across the system there are multiple forms of energy vision produced by arrangements implicated in the energy system. These can be explicit visions – encoded in the form of documents or other media – or they can be implicit. An example from the energy domain would be the way that a new build nuclear power programme produces a particular 'vision' of social order, of the role and identity of other actors and technologies that exist in relation to it (Winner, 1986). 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.

In the UK context one can therefore sketch out some of the currently dominant aspects of the constitutional arrangements surrounding the energy system. Technologically the system is still based around fossil fuel technologies and practices of domestic comfort that are influenced by meanings and practices associated with affluent consumer culture. In recent decades this system has been organized using quasi-market mechanisms, although these require complex co-ordination and state involvement to function. For some time, the dominant issue that has informed the organization of the system has been of low consumer prices. However, in recent years the issues of climate change, affordability and energy security have become salient and shaped the political considerations of energy. Engineering knowledge dominates the day-to-day operation of the system, and in seeking to address these issues, policy makers, politicians and those towards the 'centre' of the system tend to draw primarily on expert produced qualitative modelling data particularly from different sub-disciplines of economics and engineering. Under such constitutional conditions the role of publics is often framed by dominant institutions as that of passive consumers that are subject to processes of behaviour change (e.g. through social marketing or nudge approaches), or otherwise as active citizens who pose a threat to technological innovation (through resisting energy technologies such as fracking, nuclear new build, onshore wind, and so on). At the same time we see a diversity of emergent roles and public identities associated with civil society engagement in energy transitions opening up around this in more distributed forms - through community energy, grassroots innovations, activism, forms of open innovation and so on - as constitutional relations are relationally reconfigured over time.

Energy visions can themselves also be understood as arrangements, assembled from a set of different elements and inputs. A 'vision' is itself produced by an existing range of framings, knowings, doings and modes of organizing. The antecedents, framing conditions, technologies of assembly of any given vision can be traced, and a relational perspective helps draw attention to the way 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 then we can begin to understand the situated nature of all visions, and the extent to which they are partial and yet the productive effects that they have.

Whilst often associated with government agencies and the public sector, it is important to recognise that a range of different social actors produce visions of future systems, particularly in cases, such as energy, where the stakes are high and the implications are profound. For the purposes of this paper we therefore build on the 'Action Space' approach first articulated in the Transition Pathways project (see Foxon, 2013). The original action space comprised schematic of three different actor types who were engaged in the ongoing reproduction of socio-technical systems and therefore were implicated in any processes of change or transition: state, business and civil society. This paper iterates the original action space by adding a fourth actor group – science and technology (S&T). This situates researchers, scientists and technologists as active players within the reproduction of energy systems, rather than somehow being analysts and observers that stand outside of it. Our perspective all emphasises how any given actor within the system is situated at the intersection of a particular set of relational entanglements. In the case of energy visions, these extant relational ecologies are important in shaping the assumptions, choices and exclusions of all visions. In this sense each of the four actor categories are related to the identities of actors and the cultural and institutional 'settings' in which they reside -while also acknowledging the hybridity and blurring of these categories both in the making of socio-material arrangements and in practice.

3. METHODOLOGY

In order 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. Literature searches were conducted using academic databases and internet search engines in order to identify a range of different documents which explicitly articulated a vision of an energy transition - the core criterion that determined inclusion within the overall sample. A second criterion was that the proposals should link in some way to the United Kingdom either directly, or implicitly as part of a wider 'global' vision of energy system transformation. The long list of documents was then categorized according to some of the diversities outlined in Section 2 above, including

- Primary setting of lead authorial actor / collective (government, civil society, business, science and technology)
- Geographical imaginary (local, regional, national, global)
- Type of knowledge inputs (where evident)

Against these criteria three examples of a narrative created under each actor category were selected with an explicit intention of selecting a diverse corpus. Table 1 contains details of the twelve visions which briefly can be summarised as follows:

Government visions

- **The UK Transition Plan (UKTP)**: A government produced white paper from 2009 which sets out a 'national strategy for climate and Energy'. The plan sets out proposals looking ahead to 2050
- **An Energy Vision for the North Sea Region (NSV)**: An online vision that was the output of an European Interreg project involving various municipal partners from regions that border the North Sea.

- **Our Electricity Transmission Network: A vision for 2020**: A technical report produced by the Electricity Network Strategy Group (**ENSG)** which is a 'high level forum that brings together key stakeholders in electricity networks that work together to support Government in supporting long term energy challenges of tackling climate change and ensuring secure, clean and affordable energy. The report explores possible approaches to the enhancement of UK electricity infrastructure in view of rising deployment of renewable generation.

Civil Society visions

- **Zero Carbon Britain (ZCB)**: Produced by the Centre for Alternative Technology in Machynlleth, Wales, ZCB is a comprehensive vision of how the UK could be 100% renewable by 2030. An ongoing project that has been through several iterations, this analysis used the 2013 report.
- **Totnes Energy Descent Action Plan (EDAP)**: Produced by Transition Town Totnes, a grassroots project that works to make the town of Totnes more resilient in the face of climate change, fossil fuel depletion and economic uncertainty. An Energy Descent Action Plan sets out a number of key actions that can be taken going forward to build local resilience.
- **Ending Fossil Fuel Dependency (QPSW)**: Produced by the Quaker Peace and Social Witness project, this short report argues for the need to undergo a energy transition to improve justice and sustainability.

Business visions

- **Energy Vision 2013: Energy Transitions Past and Future**: This is a report that was produced by the influential World Economic Forum **(WEF)** that explores some possible ideas around the future energy Transitions. It is a 'global' vision rather than UK specific and also contains multiple perspectives.
- **Energy Futures:** Webpages which set out the energy company **EDF's** vision of the future of the UK energy system
- **The Colour of Growth: Maximising the potential of green business:** A report by the Confederation of Business and Industry (**CBI)**, a business orientated lobby group, about the the economic potential of an energy transition.

Science and Technology visions

- **Transition Pathways (TP)** Three competing narratives relating to different 'transition pathways' for the UK electricity system, each based on a different organisational logic and reflecting different technological configurations. A research project funded by the Engineering and Physical Sciences Research Council (EPSRC) and E.ON.
- **Energy 2050** A set of energy scenarios developed by the UK Energy Research Council (**UKERC**) which explore possible future energy trajectories in the UK, primarily generated using the UK MARKAL-MED model.
- **Deliberating Energy System Transformation in the UK (DEST).** A qualitative research project, also funded by UKERC, which explores public attitudes in relation to various aspects of an energy transition.

Each of the visions was subject to a textual analysis, which was structured around a set of pre-defined categories that were informed both by our relational co-productionist approach, and by other literature on visions, namely:

- Issues and matters of concern motivating the energy transition
- Proposals relating to (material) technologies
- Proposed governance tools and arrangements
- Knowledge inputs and outputs
- Roles of different actor groups, including civil society and publics

Using these sensitizing categories a discourse analysis 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). This interpretive exercise was primarily focused on the explicit presence or absence of different elements or concepts. This paper is intended as an exploratory study to illustrate the benefits of mapping across a range of sociotechnical visions that extend beyond the dominant societal narratives and this approach is not without its challenges. Our analysis has necessarily focused on explicit articulations. Implicit assumptions are only included where they can be clearly discerned and even then, there would likely to be differing opinions between analysts as to what can be 'read into' the competing vision. The vision vary in their specificity in relation to different elements of the visions and attempting to compare twelve very different visions through a common lens inevitably requires some interpretive decisions to be made. The fundamental uniqueness of each situated vision underpins this particular approach, and therefore would predicate against the drawing of too many generalized conclusions. Twelve documents is a sufficient sample to support an exploration of some of the dimensions of diversity, but any broader generalizations are tentative and qualified. Finally, a relational co-productionist approach would point to the inevitable hybridity of all collectives. In this sense the use of the 'settings' is a somewhat artificial distinction, but one which usefully points to some kind of important distinction related to the institutional and cultural situation and entanglements of each particular vision.

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
STATE	**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, available at http://www.energyvision.info/index.php/results (last accessed 24/08/15)
	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 24/08/15)
BUSINESS	**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 24/08/15)
	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, available at: http://www.edfenergy.com/energyfuture/ (last accessed 24/08/15)
	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.cbi.org.uk/media/1555286/cbi_-_the_colour_of_growth_-_maximising_the_potential_of_green_business.pdf (last accessed 24/08/15)
SCI & TECH	**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)
CIVIL SOCIETY	**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, (Machynlyth, Centre for Alternative Technology
	EDAP	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:http://www.quaker.org.uk/files/Fossil-fuels-anchor-briefing-FINAL.pdf (last accessed 24/08/1

4. MAPPING DIVERSITIES IN ENERGY VISIONS

4.1 Scope of vision

Figure 2 summarizes some key elements of each vision visually, showing the presence or absence of some of the major themes, plus, the shading of the 'petal' showing whether or not that particular dimension of change is included within the vision (see Figure 3 for a key). 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 economic growth.

These are organised vertically in the four settings of the action space. Narrower visions are therefore those with fewer shaded petals and fewer dots. Figure 3 shows that the 'narrowest' vision (in terms of the elements contained) is that of the Quaker Peace and Social Witness project. This vision represents an argument for a need 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 organization 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 detail 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 socio-technical 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 dimensions is now discussed in more depth.

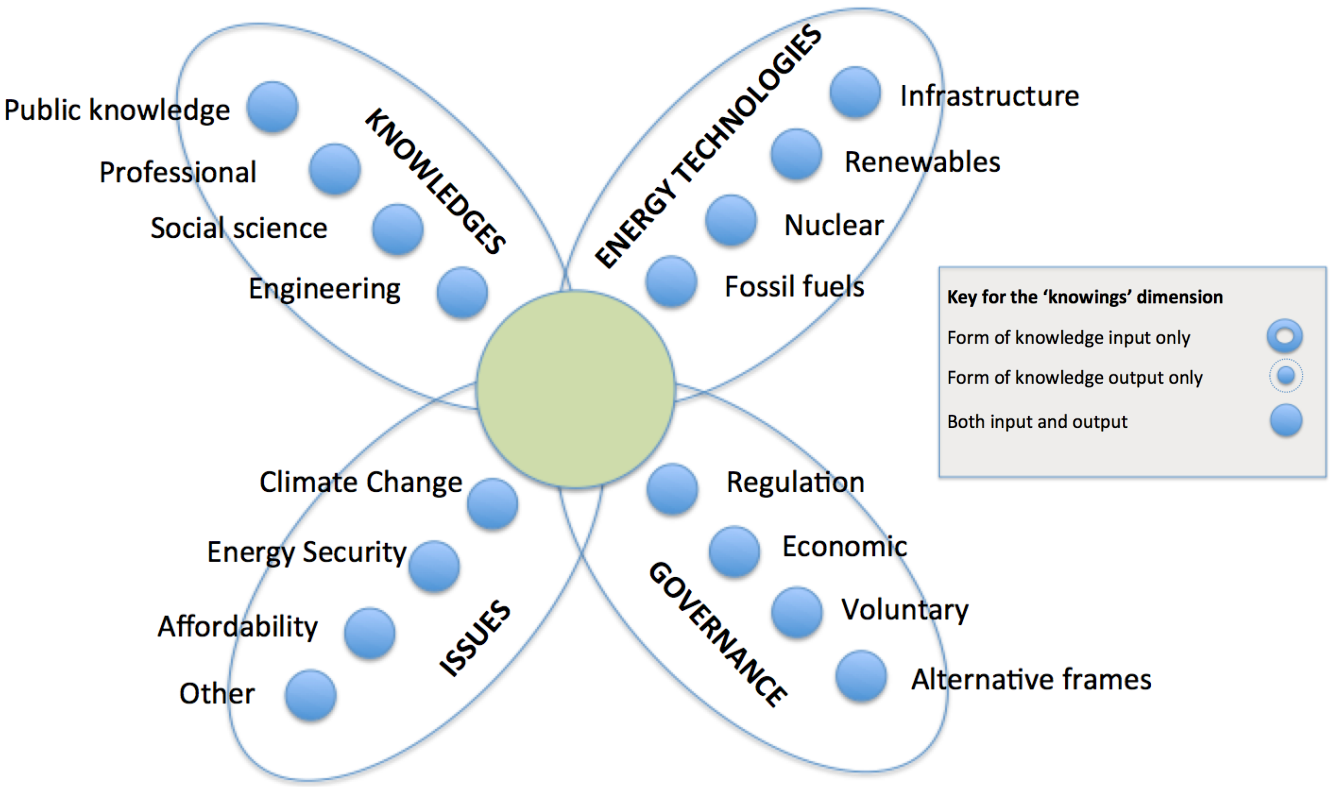
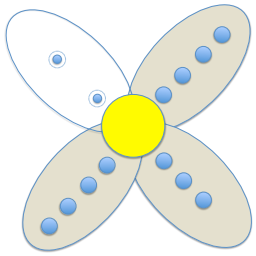
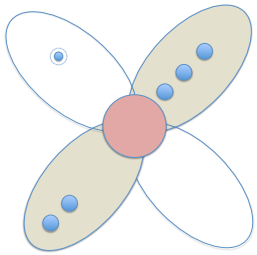
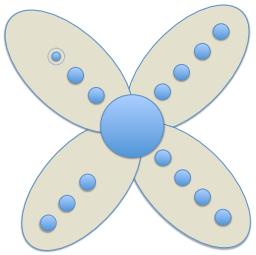
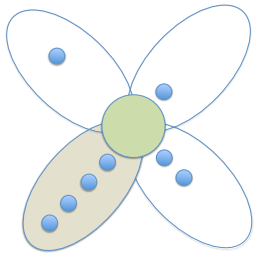


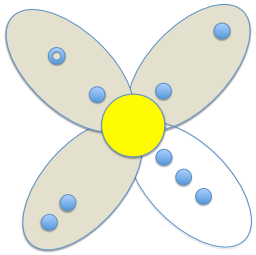
Figure 2: Key to co-productive dimensions of different energy visions diagrams (see fig. 3).

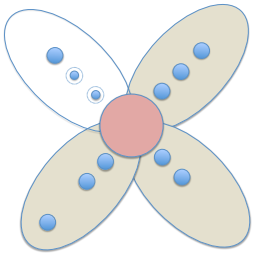

UK Transition Plan

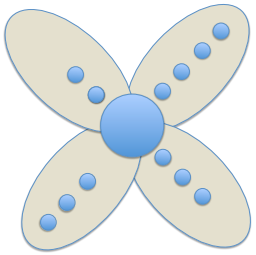

EDF

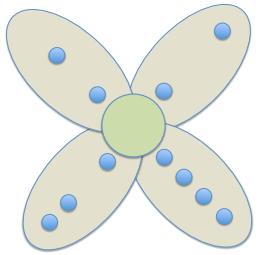

Transition Pathways

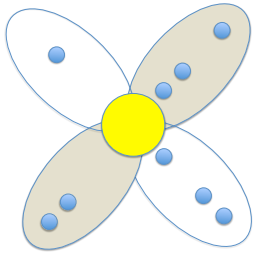

Quaker Peace & Social Witness

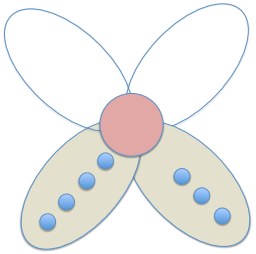

Electricity Strategy Network Group

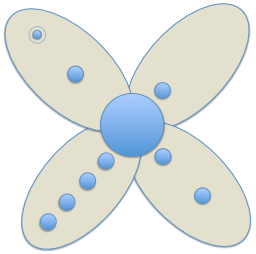

World Economic Forum


UK Energy Research Centre


Zero Carbon Britain


North Sea Vision


Confederation of Business and Industry


Deliberating Energy System Transformation

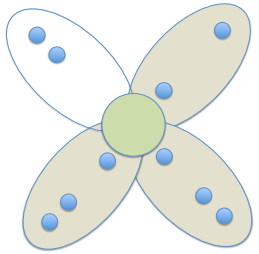

Totnes Energy Descent Action Plan

Figure 3: Co-productive dimensions of energy transition visions

4.2 Meanings: Issues motivating the energy transition

By including 'meanings' as one of its four dimensions, the 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 issue or 'matters of concern' that is being articulated by the corpus: Environmental issues, energy-related and economic. Climate change was the only issue that was invoked by all twelve 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 the impact 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 feature 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, 2010). Table 2 shows that the civil society visions do not re-produce the energy trilemma and instead open up a broader range of issues.

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										✔	✔	✔

In contrast to the narrative around energy security - which 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 form 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 our over reliance on fossil fuels and the likelihood of 'Peak Oil' which will lead to increasing costs and scarcity (Hopkins, 2008). This problematisation therefore relates to 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 (EDAP)). 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.

The visions which originate from the business setting are neither as narrow as those based primarily around the trilemma nor broad as those originating from 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 focus 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 in order to support economic growth is also an explicit rationale of the CBI vision. In contrast, the civil society visions provides an interesting and diametrically opposite rationale, arguing that the transformation of the energy system is necessary in order 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).

4.3 Doings: Material technologies

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

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				✔			✔					

All visions 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 renewables technologies, but this is a reflection of its function as an appraisal of the energy system that illustrates that a 100% renewable energy system is technologically feasible. 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. In order 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. 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 ongoing integration of energy and communication technologies, leading to increasing numbers of visions of 'smartness' around energy production and consumption. Secondly, visions produced in three out of the four settings emphasize 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 infrastructure in order to facilitate the growth and maintenance of offshore wind. Visions associated with all four settings also include some kind of reference to transport which emerges as the system that the visions , but in the most part this fairly 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.

4.4 Organizings: Governance arrangements

The governance arrangements proposed by each vision have been coded in our analysis according three conventional categories of policy instruments: regulatory, economic, voluntary (e.g. see Skea *et al.*, 2011), in addition, one further category emerged from our inductive analysis of the data which we have labeled '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 related to the potential role for new forms of measuring 'progress' beyond simply measuring Gross Domestic Product (GDP) such as quantifying 'wellbeing' or 'happiness' (Layard, 2005).

Table 4 illustrates the wide diversity of different points and mechanisms that are imagined as effective strategies for the governance of energy systems. Overall, the most popular categories are 'new regulation', 'carbon accounting and taxation' and 'stimulating low carbon investment'. In terms of patterning across the different settings Table 4 illustrates that generally all three main kinds of governance instrument are recommended across the 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 twelve visions with several different kinds of carbon management techniques proposed across the whole corpus. However, one clear distinction can be discerned relating to the allocative 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, 1990). In contrast, the state and academic visions focused on the more established (market based) mechanisms of carbon accounting, trading and 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 and allocated.

Table 4: Proposed governance approaches for steering the energy system

	UKTP	ENSG	NSV	WEF	CBI	EDF	UKERC	TP	DEST	ZCB	QPSW	EDAP
REGULATORY	✔	✔	✔	✔			✔	✔	✔	✔	✔	✔
New regulation	✔			✔			✔	✔		✔	✔	✔
Carbon rationing										✔		✔
De/re-regulation		✔	✔				✔					
Policy coherence			✔	✔								
ECONOMIC	✔	✔		✔	✔		✔	✔		✔	✔	
Carbon accounting and taxation	✔	✔		✔	✔		✔	✔		✔	✔	
Consumer incentives	✔				✔							
Stimulating low carbon investment	✔			✔	✔		✔			✔	✔	
Market related	✔			✔			✔	✔				
Energy pricing / charging		✔		✔						✔		
Funding research				✔			✔					
Green New Deal							✔			✔		
VOLUNTARY	✔	✔	✔		✔		✔	✔	✔	✔		✔
Voluntary action by citizens								✔		✔		✔
Competitions	✔											
New forms of partnership			✔				✔	✔	✔	✔		
Information and education	✔		✔		✔				✔			
ALTERNATIVE FRAMES			✔		✔			✔		✔		✔
Alternative metrics and measurements								✔		✔		✔
Visioning the future			✔		✔							✔

4.5 Knowings: Energy Knowledges

Table 5 illustrates how different forms of knowledge are entangled in visions of the energy transition. Firstly, where these are clearly defined, it shows the knowledge inputs which went into constructing the visions. Secondly, 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.

Table 5: Knowledge inputs and outputs in the corpus of energy visions

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

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. Contrastingly, in the civil society setting, the EDAP 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 have a tendency 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 twelve 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 popular ways of 'knowing' the energy system.

4.6 Summary

This section has highlighted some of the key patterns of presence and absence across the corpus of twelve energy transition visions. Four core commonalities can be discerned and which perhaps represent the shared elements of a broader energy transition narrative. However on each of these points there is a large degree of variance too. These are as follows:

1. **An energy transition can be managed.** To a greater or lesser extent each of the energy visions contains the implicit assumption that it possible to manage an energy transition through possible interventions in the 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.
2. **Climate change is a problem that needs to be addressed.** Climate change is the one issue that is shared by all twelve 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.
3. **The energy transition involves the expansion of renewable energy.** All visions propose some kind of shift towards a more renewable based energy system. Where the vary, is on how far this can go, the exact configuration of technologies, and the role for other energy sources including fossil fuels and nuclear, and CCS.
4. **The management of carbon is an important part of the transition.** 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 significant points of divergence have also emerged across the corpus:

1. **Competing models of societal progress** - based either on the continuation of, or rejection of economic growth
2. Attention to the **distributional costs and benefits of the transition** - recognition of issues pertaining to energy justice and equity, but also in terms of procedural justice and inclusion. Some visions explicitly see a role for public knowledge whereas others are more technocratic.
3. The difference between **more centralised and more distributed energy configurations**, in relation to both the technological preferences and the associated governance arrangements.

The next section explores some of the broader analytical themes which emerged from the analysis of the diversity of the visions.

5. ANALYSIS AND DISCUSSION

5.1 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. Reading across the corpus of visions provides contrasting examples of the way in which 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 recognizes 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, the 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 centralized large scale energy technologies tend to 'produce' an implicitly centralized and technocratic socio-political 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 different configurations of governance instruments that exist in relation to a given technology. This can be seen in the multiple different mechanisms in which solar technologies can be deployed, from community based ownership to corporate investment models (Hess, 2013).

The exploration of the issues that motivate energy transition visions in section 4.1 suggests that that low carbon transitions are not narrow single-issue controversies but should be understood as broader political situations (Barry, 2012) where there is an inter-linkage of multiple issues. The significance which different actors attribute to different particular issues and the associated risks inevitably shapes their vision, for example the risks of climate change or nuclear energy. These assessments therefore inform particular logics and rationale that then shape particular technological and governance proposals that are then developed. For example, the deeper problematisation of fossil fuels found within the civil society visions leads to their 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 evidence of the way in which energy and economic systems are deeply entangled, e.g. through the way in which neoliberal governance logics has shaped the energy system.

5.2 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, and the energy 'system' more generally, are situated and partial. The socio-material '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 6 points out some commonalities across the visions produced in the different settings.

Table 6: Shared elements of visions within different settings

	Shared elements of visions
State	• Energy security as an issue • Focus on infrastructure • Focus on cost / economics of transition
Market	• 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

Whilst there is some difference in the different perspectives produced by each setting, to some extent all of the visions are shaped by the existing constitutional arrangements insofar that they contain aspects of the currently dominant ways of knowing, doing and organizing energy, along with the meanings and frames associated with it. 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 recognizably reproduce the dominant socio-technical imaginaries associated with energy. So we see the Low Carbon Transition Plan offers a technological fix (dependent on Carbon Capture and Storage), based around a narrower set of issues (the 'trilemma'), organized using market based mechanisms with the wider objective of using the trilemma to support economic growth. In contrast, as a general rule (see figure 1), 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 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 offers a socio-technical imaginary which varies from the dominant 'centred' vision: one which proposes socio-cultural change instead of techno-fix, opens up a broader set of issues including peak oil, equity, and broader sustainability issues, is organized around voluntaristic and rationing based systems and argues that the transition is required to shift society away from an unsustainable capitalist development (See table 7 for a summary of the two different positions).

Table 7: Contrasting dominant and alternative imaginaries of 'the energy transition'.

Element	Dominant imaginary	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.

Reflecting on the way in which different energy visions are situated draws attention to the way in which 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 nearer the dominant societal imaginaries than the peripheral / alternatives ones. A certain degree of similarity between the S&T visions and the government visions can be observed. For example, in relation to the categories in Table 7, the S&T-related visions tend to replicate the dominant imaginaries of an energy transition, rather than those that represent an alternative perspective. This is significant because, in theory, there is the belief 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 scientists to underplay the significance of their science and rely on unproven negative emission technologies (such as Carbon Capture and Storage) in order 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 the dominant socio-technical imaginaries. The association between less structured space and more radical forms of innovation is a core element of niche innovation theory (Smith and Raven, 2011). In socio-cultural 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.

5.3 Imaginations of actor collectives

The situatedness of each vision can also be read through the different actors which are present or absent, and the different ways in which they are framed. From each particular site within the wider 'system-as-assemblage' certain actors are 'visible' whereas others are not. Unsurprisingly, central government are the most visible actors across the corpus, and are often attributed both power and responsibility in relation to the steering of the energy transition. In most cases this related to ideas around getting the policy framework right and providing certainty and direction for an energy transition. This reflects the recognition that national governments do have the power to (attempt) to shape the actions of other actors through legislative and other regulatory devices. In some cases it was felt that a key function of the national government was to show political leadership. Local authorities are given a more significant role in some visions, such as the municipality produced NSV and the EDAP which is very locally situated at the level of a locality. The EU and supra-national political influence is mostly absent across the corpus, which is perhaps surprising when the increasing transnational energy interconnections are considered (Helm, 2003). Whilst the government are present in most visions what is also notable is the absence of imagined actor collectives who are currently implicated in the management of the energy system such as the National Grid or Elexon (who administer the wholesale electricity market via the Balancing and Settlement Code). There was a great

deal of divergence amongst the visions in relation to emergent forms of energy organisation, and no single idea emerged more than once. This suggests that there is recognition that some kind of new institutional arrangements are likely to be needed, but it is not clear what exactly these will look like. The TP vision offered most in terms of new institutions, articulating the possible role for a 'Strategic Energy Authority' in a state led transition pathway and the role of Energy Service Companies (ESCOs) in a distributed system. Some visions articulate new roles for civil society actors within the transition process including carsharing (ZCB) and community participation in energy production (ENSG, TP). New forms of business model and network are also anticipated by UKERC (in relation to energy efficiency) and NSV (in relation to networks of SMEs). Overall, there is a sense from the corpus that social re-organisation is expected but that its actual anticipated shape is much less clear.Turning to imaginations of the public, it is also evident that there is a great deal of divergence in the way in which their roles in the energy transition are imagined. At a basic level there is the extent to which they even feature within the imagined transition process. This varies from vision to vision, from those which are predominately orientated around the roles of the public, where they are active agents of change (e.g. EDAP), to those where publics are almost entirely absent from the future vision (e.g. the technical ENSG). Across the 12 visions included in our analysis four distinct imaginaries of publics and their roles energy transitions were evident:

- Passive-consumers: Publics are imagined primarily in a passive role as consumers at the 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 realize that there is a public that needs to be consulted and create the opportunities to do so.
- Active-publics: Publics are perceived as active agents who can contribute to, or undermine, the transition.

Table 8 shows how these distinct imagined public identities relate to the different settings in which the visions of energy transitions were produced.

Table 8: Imaginaries of the public in visions of energy transitions.

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

Some basic patterning of the different imaginaries across the four settings can be observed. Firstly, it is clear that the civil society visions tend to produce a positive view of the role of publics within the energy transition. These visions tend to envisage the that the public can show a leadership role, as well as practically engaging in the transition in a number of different ways. For example, as energy producers (prosumers) or as participants and supporters of community energy projects. As these visions tend to fall into the alternative paradigm (table 7) where it is clear that there is envisaged relationship between a decentralized system and 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. Contrastingly, 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 in order 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). TP is the academic vision that opens up the most diversity of roles for the public, primarily through the inclusion of the 'Thousand Flowers' narrative which envisages a more distributed system that does involve a certain degree of public participation. Even so, more detailed work on the possible institutional configurations required to support a more distributed system point to the fact that state involvement will always be necessary and significant, highlighting the hybridity of all pathways in terms of the mixture of different actor types and their 'logics' (RTP Engine Room, 2015). The state located 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 the public, mostly constructing them as passive energy consumers rather than more active participants in the system.

Finally, it is interesting to note that there are some forms of public that are neglected across all twelve visions (See Walker and Cass [2007] for a comprehensive review of the multiple roles that publics can play). As Table 8 illustrates, only one vision explicitly suggested that publics should be consulted through the construction of specific participatory spaces, although the DEST vision itself was the product of such as process. The idea that the public can be beneficiaries of new energy provision relates to the idea that they can benefit from agreements with developers, for example in the case of onshore wind. A relatively recent development in the UK, this does not appear as an imagined role within the corpus of examined documents. Similarly, the role of public as investors is also not an imagined role in the UK context, where there are few established mechanisms for local energy investment. This contrasts with the Energiewende in Germany for example where there are more diverse financial institutions (Hall *et al.*, 2016). This is a useful illustration of the way in which the dominant modes of governance and relations between technologies and actors can vary between different forms of (national) constitutional arrangement, shaping the different possible boundaries of the visions.

6. CONCLUSIONS AND IMPLICATIONS FOR REALISING TRANSITION PATHWAYS

This paper has sought to explore the diversities that exist around completing visions of an energy transition, with a particular reference to the UK context and the Realising Transition Pathways project. Using a relational co-productionist approach it has sought to expose to illustrate how multiple actors across energy systems produce different visions of what an energy transition might entail and, in many cases, work actively to shape the system according to the vision. By placing these visions alongside each other, and exploring them comparatively, the paper has provided some important insights into (i) the nature of energy visions and scenarios as a phenomena; (ii) How the RTP pathways relate to a wider body of energy transition work; and (iii) the way in which energy vision research should be undertaken. Each of these will be addressed in turn in conclusion.

Reading across the corpus that this paper has explored, it is clear that visions of energy transitions are situated and partial. Their partiality is reflected in the way that they bound the system, and the inclusions/ exclusions they make in terms of meanings, knowings, doings and organizing. Furthermore, they are partial in their recognition of which actors are relevant and involved in the transition process. Whilst there are some strong threads and commonalities that run through many if not all of the visions, there are also diversities in the meanings, motivations and solutions. The complexity of an energy transition means that every single vision is an exercise in bounding the system – in delineating the elements that are deemed most relevant and important (Leach et al., 2010). Indeed, the partiality of all energy visions – and the inability to account for the complexities of change - is one important reason for the general unreliability of future predictions around energy (Grossman, 2013; Smil 2000). The decisions that are made in relation to these inclusions and exclusions are often heavily shaped by the situatedness of the vision. The setting in which it is produced can have an important role in shaping the contours of the vision. It is in this way that we can see relations to other actors, and more generally to the extant system and constitutional arrangements, influence the particular shape of any given vision. Energy visions themselves also co-produce social orders – legitimizing and bringing forth particular imaginaries of social order. This occurs both explicitly – through the particular configurations of social order that are proposed, but also implicitly, both through the unspoken social assumptions (e.g. perpetual economic growth) and through the technological proposal, which themselves imply certain forms of social order. The diversities and co-productive nature of all energy visions needs to be attended to reflexively in future anticipatory energy research and policy. Indeed, one purpose of this paper is to bring this kind of analysis to the Transition Pathway project, by situating the pathways within a wider corpus of competing energy visions.

Comparing the TP pathways to the wider corpus it is evident that they are in many ways one of the broader visions. The device of three different pathways opens up a broader diversity of possible actors, system logics and institutional configurations. Indeed, the existence of the more distributed Thousand Flowers pathways also means that the public are envisaged as active participants. However, building on the insights detailed above, we can reflect on the inevitable partialities of these particular visions. Whilst the RTP pathways are strong on the technical details of the imagined transition, much less attention has been paid to the governance mechanisms which would steer the process. Furthermore, whilst there is diversity within the pathways, as a whole they are much closer to a 'mainstream' vision of what an energy transition might look like compared to the more radical visions that emerge further from the centres of power and calculation. For example, the narrower framing of the issues around the well established 'trilemma', the assumptions around economic growth and the techno-optimism that the 'speculative' impact of Carbon Capture and Storage which enables the continued consumption of fossil fuels. But it also reflects the proximity between the setting of the RTP project and the government bodies which fund and are the focus of such research, and the way in which, as has been pointed out above, research is produced which conforms with the political and economic priorities of its core audience (Anderson, 2015).

When reflecting on the process of pathway development one participating researcher observed that ultimately the Transition Pathways were less experimental and radical than they might have otherwise been, that the space between them was fairly narrow (Longhurst and Chilvers, 2012). In many ways this reflects the way in which the academic setting – with its conventions around knowledge production, 'objectivity' and rigour – have shaped the emergent pathways. Such reflection on the partiality and situatedness of the TP analyses, and on the inherent social assumptions and imagined forms of social order inscribed within them, should become a feature of transition pathways work and attempts to publicise the RTP project findings.

So what lessons might be learned for the way in which future energy pathways might be undertaken in the future? There are, we think, three important pointers that can be taken forward. The first is a call for reflexivity. Scientists and researchers who produce visions of energy transitions are themselves part of the system. Their research becomes codified, encoded into texts and travels, doing work in terms of influencing actors and, potentially, the socio-material configurations of the system. Recognising this positionality, acknowledging the way in which it shapes the process and outcomes, and reflecting on the inevitable exclusions and boundaries are all aspects of the necessary reflexive stance towards energy futures work. This leads to a second insight – the need for transparency. These partialities should be explicit and clear. Claims for comprehensiveness and objectivity should be abandoned for a more measured, reflective and humble stance that openly acknowledges the limitations of any given piece of work and the often implicit assumptions that are contained within.

More broadly then, this suggests that, taken in isolation, narrow technical appraisals are never going to be sufficient to fully explore the socio-political implications of energy transitions and the contestations that arise. Even the narrowest, most quantitative, most technical appraisal of an energy future, is inevitably entangled in the politics of energy change and brings forward normative assertions about desired social and political futures. In seeking to combine the strengths of qualitative modeling with quantitative scenarios, the RTP project made a step forward in attempting to move beyond the technologically focused modelling approaches that reflect the dominant knowledge form in UK energy research (Taylor *et al.*, 2014). However, as noted above, the RTP pathways, like any given vision, have their own partialities, with narrower explorations of the meanings and organizational dimensions of the energy transition. The implication for energy research is that these diversities need to be recognized, acknowledged and opened up, even if there are consequent closures around certain proposed courses of action or socio-technical configurations.

This opening up can occur at different points in the process. Within the development of transition visions, specific methodologies can be employed to explore the range of diverse perspectives that exist around a given issue such as energy such as Q Methodology or deliberative mapping (Burgess *et al.*, 2007). The objective here is to map and acknowledge the diversities that exist, and from which a more diverse range of pathways or scenarios might be elaborated. Similarly, from a policy perspective, there is a opportunity to actively seek out different perspectives and visions, rather than rely on those only from the Science and Technology setting, which, as this paper has illustrated, tend to echo back the priorities and prerogative of governments and research funding bodies. For example, in the case of the potential points of intervention within the energy system, reading across multiple visions not only opened up a broader discussion about how ‘carbon’ might be managed, but also drew attention to a multiplicity of possible mechanisms and sites of intervention. An exploration of the disjunctions, differences and commonalities around a wider set of visions brings into focus the key areas of divergence, and the critical issues that are at stake. Any attempt to steer energy systems that fails to recognize these concerns and key axes of difference is likely to fall short, and potentially overlook ideas, actors and interventions that could contribute to a wider collective endeavour.

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