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Perspectives

Critical perspectives on disruptive innovation and energy transformation

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ABSTRACT

What are ‘disruption’ and ‘disruptive innovation’? And what relevance do they have for energy transformation? Ten critical perspectives offer ten contrasting responses to these questions. The relevance of Christensen’s canonical definition of disruptive innovation is highly contested in its applicability to energy and climate challenges, as is the usefulness of analysing discrete business models or technologies rather than socio-technical systems. Further research on disruptive innovation and energy transformation needs to tackle: (i) the social, systemic and emissions impact of widespread adoption; (ii) how to mitigate the adverse distributional consequences of disruption; (iii) the consumer appeal of ‘good enough’ products for users marginalised or excluded from mainstream markets; (iv) the role of incumbents in system transformation; and (v) the reasons for geographic variation in disruption processes currently underway.

1. Introduction

Needs and expectations for energy system transformation keep mounting. The bar has been raised still higher by the Paris Agreement’s aspirational aim for 1.5 °C mitigation and the Sustainable Development Goals’ energy access for all. Rapid, deep, and pervasive changes to the way energy is resourced, converted and used require marked discontinuity from current trends [1,2]. But does a sustainable energy future imply ‘disruption’?

Innovation is conceived of most simply as novelty, or more formally, as “putting ideas into practice through an iterative process of design, testing, application, and improvement” [3]. Innovation is a central element in sustainable energy narratives and activities. Alongside the Paris Agreement, the G20 signed up to ‘Mission Innovation’ and a doubling of public R & D investments to ‘accelerate the clean energy revolution’ [4]. Many emerging innovations – from decentralized electricity generation and electric vehicles to peer-to-peer business models and digitalisation – are frequently labelled as ‘disruptive’ [5]. But ‘disruptive innovation’ is a slippery term used differently by entrepreneurs, incumbents, regulators and academics, and applied variously to technologies, business models and sociotechnical systems. Shorn of its association with innovation, ‘disruption’ also takes on a very different and largely negative connotation.

So what are ‘disruption’ and ‘disruptive innovation’? And what relevance do they have for energy transformation?

This Special Section on ‘Disruptive Innovation and Energy Transformation’ offers ten Perspectives on what disruption and

disruptive innovation mean, and whether they are useful lenses for examining the sustainable energy challenges of our time. The Perspectives were invited from authors with a range of backgrounds who were given free rein to articulate their views subject to two constraints: they had to explain how they interpreted the terms ‘disruptive innovation’ and/or ‘disruption’; and they had to explore whether and how they thought either term was relevant for energy transformation. As Perspectives they are intended to be “*opinion-like pieces on a ‘hot’ topic, introducing new concepts, ideas and findings to the field of energy studies*” (ERSS Editorial Guidelines).

The collective result is an illuminating set of arguments and counterarguments, touching on Christensen’s canonical definition of disruptive innovation, but then departing in critical and often intriguing directions. Clayton Christensen, a leading business and management scholar, popularised the term ‘disruptive innovation’ to describe low-cost, low-end goods and services which appeal to consumers marginalised or excluded from mainstream markets [6]. Historical examples of disruptive innovations – from microcomputers to discount retailers – illustrate their transformative potential. Could analogous disruptive *low-carbon* innovations help transform energy systems? The Perspectives in this Special Section explore this question in depth, and reach conclusions ranging from a circumspect yes to a categorical no. But it is the arguments why which are important.

To be clear, this is not an abstract or theoretical debate. Energy transformation requires directed, aligned, multi-scale efforts to innovate more sustainable ways of producing, distributing and using energy. Consumers are an elephant in the room: at best, consumers are

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Table 1
Three streams of critical perspective on disruptive innovation and energy transformation.

		Stream	Object of analysis	'Disruptive innovation' as ...
increasing scope	(3)	and beyond ...	wider elements or implications of disruption and innovation	... as inescapably political, falsely seductive, and with potentially significant unintended or undesirable consequences
	(2)	to socio-technical systems	interactions between niche, regime and landscape levels opening up (or closing down) opportunities for system transition	... as narrowly concerned with minor point-source change compared to reconfiguration of socio-technical systems with social, political, cultural and infrastructural dimensions
	(1)	from technologies and business models	technologies and business models offering goods and services with novel attributes to consumers	... as alternatives to mainstream forms of service provision and incumbent service providers

a neglected constituency in societal efforts to meet climate and other policy objectives; at worst, consumers are imagined as an unsurpassable barrier to sustainable transition in ways that are arguably self-fulfilling – consumption (of energy- and material-intensive goods and services) is at the heart of the problem. Yet disruptive innovation is a field of business and management scholarship specifically interested in the transformative potential of novel goods and services and their spontaneous, if surprising, adoption by consumers. Exploring the applicability of disruptive innovation to energy transformation is relevant, timely, important ... and as this Special Section reveals, highly contested.

As a first systematic attempt to apply disruptive innovation concepts to energy transformation challenges, it is not surprising this Special Section reveals ambiguous definitions, contrasting interpretations, and outright disagreements. Differences in perspective crystallise most clearly around issues of scale and scope. Are technological and business model innovations (in Christensen's mould) a useful analytical entry point? Or does the scale of the challenge require a systems perspective which rejects the primacy of discrete innovations in effecting change?

The ten Perspectives can be broadly channelled into three streams depending on how they answer these questions (Table 1).

One stream follows Christensen's arguments on novel goods and services to examine their emission-reduction potentials in consumer-facing markets [7,15] or in communities [8].

Another stream largely or wholly rejects the applicability of innovation-centred analysis of energy transformation in favour of a socio-technical systems perspective in general terms [16–18] or specifically in cities [9].

A third stream diverges like a delta beyond the innovation-focused or systems-focused dichotomy, and explores some broader aspect of disruption and energy transformation: scenarios and disruption from without [10]; politics and power/knowledge [11]; narratives and continuity [12].

In compiling this Special Section, we have opted not to go for the sequential organisation of the ten Perspectives into these three streams. Instead, we have ordered the Perspectives cyclically from innovations, to systems, to beyond, and then back again (Fig. 1). Admittedly, few readers may read this Special Section linearly from start to finish. But we hope that this ordering may encourage you to do so for a critically engaging series of argument and counterargument. For although they were written separately and in parallel, the Perspectives undoubtedly speak to each other – in tones ranging from agreement to disagreement and 'ah, but what if you considered this'. We have not added cross-references between the Perspectives, preferring to confine our editorial comments to this introduction, and allowing dialogue and tension to emerge from the reading.

The origins of this Special Section lie in two back-to-back workshops held in London in March 2017, organised by Future Earth and the Tyndall Centre for Climate Change Research, with financial support from the UK Science & Innovation Network. The workshops explored the potential contribution of disruptive innovation to reducing carbon

emissions. The first workshop brought together low-carbon start-ups, incumbents, investors, market intermediaries, and policymakers in different domains including mobility, cities and energy supply. The second workshop brought together researchers working on low-carbon innovation and system transformation, particularly in the energy domain. Full details of the workshops are available in [13] or via silci.org; see also Box 1 on how to contribute to this debate.

The two workshops took strikingly different perspectives on disruptive innovation and its applicability to climate change mitigation. For innovators, disruption was seen as an inherent characteristic or consequence of innovation rather than anything distinctive and worthy of specific attention. For researchers, disruptive innovation was highly contested. Neither workshop accepted wholesale the applicability of Christensen's arguments for addressing climate change. How can one of the six best business books ever written [14] not resonate with innovators and researchers actively working on low-carbon innovation and system transformation?

This Special Section explores the answer in depth. Some of the authors participated in the workshops; others did not. But regardless, their brief was the same: provide an opinionated but substantiated Perspective on 'disruptive innovation and energy transformation'. Here we provide our own brief summaries of the ten Perspectives as guideposts for the reader, in order of how they appear in the Special Section.

Charlie Wilson expands on Christensen's definition of disruptive innovation, and maps it onto the challenge of reducing carbon emissions ([15]). He notes that 'disruptive' and 'breakthrough' are terms often used interchangeably to describe novel technologies in breathless Silicon Valley terms, but this conflates an emphasis on users and markets (disruptive) with an emphasis on hardware and software (breakthrough). This conflation is reinforced by discussions during expert workshops which revealed many unresolved tensions with disruptive innovation concepts, not least in the required role for public policy.

Frank Geels identifies several important limitations with Christensen's framework applied to the challenge of energy transformation ([16]). He argues that Christensen: is narrowly concerned with single products rather than systems with interacting innovations; focuses on market competition and so omits important social, cultural, and political influences on demand, including low-carbon energy and innovation policies; takes a 'point source' approach to change which overlooks how innovations and supposed 'heroic' innovators align with broader processes such as political struggles and societal debates. Geels goes on to explain how the multi-level perspective overcomes these limitations by offering a comprehensive account of how complex socio-technical systems change.

Mark Winskel contextualises interest in disruption within a historical trajectory of innovation scholarship from Schumpeter to the current emphasis on socio-technical transitions ([12]). He notes that the disruptive entrepreneur or niche firm still play important roles in innovation systems and transition theories of change, with incumbents cast as inert, resistant, or limited to incremental change. He goes on to

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