Energy Research & Social Science 22 (2016) 232–237

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

Short communication

Further reflections on the temporality of energy transitions: A response to critics

Benjamin K. Sovacool[a,b,*], Frank W. Geels[c]

[a] Department of Business Development and Technology, Aarhus University, Birk Centerpark 15, DK-7400 Herning, Denmark
[b] Science Policy Research Unit (SPRU), School of Business, Management, and Economics, University of Sussex, United Kingdom
[c] Sustainable Consumption Institute, Manchester Business School, The University of Manchester, United Kingdom

ARTICLE INFO

Article history:
Received 22 August 2016
Accepted 22 August 2016
Available online 25 October 2016

Keywords:
Sociotechnical transitions
Energy transitions
Energy transformation
Energy substitution

ABSTRACT

In tandem with the call for more careful, thoughtful, reflexive thinking on the topic of energy transitions, in this paper we attempt to unpack some of the themes advanced in this Debate. We begin by investigating the multi-dimensionality of energy transitions as well as transition speeds for different parts of energy systems at different scales. We then call on analysts to consider transition speeds and scalar levels. We also argue for focusing on accelerated diffusion driven by rapid changes in cost, improvements in technology, or other factors.

1. Introduction

Sarrica et al. [1] have advanced our understanding of energy transitions across individual, community, national, and even theoretical planes, and Sovacool [2] has attempted to facilitate a critical albeit reflexive and productive discussion about the timing and temporal dynamics of energy transitions. Messengers Grubler et al. [3], Smil [4], Kern and Rogge [5], Fouquet [6] and Bromley [7] rightfully build and challenge some of the arguments presented in the Special Issue on energy transitions this journal published a few months ago.

However, when Grubler et al. [3] argue that "Sovacool's strawman comparison between the slow dynamics of global primary energy transitions and the seemingly rapid dynamics of national end-use and resource transitions fail to account for ... important determinants" and Smil [4] adds that "[Sovacool's] wishful thinking is contradicted both by indisputable statistics and by the imperatives of energy conversions," a partial defense is in order. The central argument advanced in Sovacool [2] was not that quick transitions determinedly happen, but that there are two almost mutually exclusive academic discussions on the topic, one of them aligned with Grubler, Smil and others about the lengthiness of transitions; and another with separate scholars arguing in favor of speed (with Bromley [7], Kern and Rogge [5], and even Fouquet [6] furthering some of these claims in their new contributions). In the extreme, one could even criticize this academic dichotomy as "hard historical facts" versus "normative, future-orientated desires."

We suggest, however, that these two tracks represent a deeper difference between techno-economic analysis (focused on 'tangible' elements) and socio-institutional analysis (focused also on 'intangible' elements and actors) with important implications for differences between historical and future transitions, which we discuss below. The "How Long Will it Take?" article was an attempt to draw attention to these tensions: it was not meant to present one side as determinable truth, only that the answer to the question will depend on fundamental definitions and assumptions—what some recent work has called intellectual, cognitive, or epistemic frames [8–12]—that are not always as transparent or apparent as they need to be. In that regard, despite perhaps misrepresenting the central purpose of that article, the six pieces here in this special "Debate" in the journal are apt and insightful; the advancing intellectual dialogue hoped for has been accomplished.

In line with the need for more careful, thoughtful, reflexive thinking on the topic of transitions, in this paper we attempt to unpack some of the themes advanced in this Debate. We begin by investigating the multi-dimensionality of transitions as well as transition speeds for different parts of energy systems at distinct scales.

2. Multi-dimensionality of transitions

Geels and Schot [13]: 12 note that "transitions are co-evolution processes that require multiple changes in sociotechnical systems

* Corresponding author at: Department of Business Development and Technology, Aarhus University, Birk Centerpark 15, DK-7400 Herning, Denmark.
E-mail address: BenjaminSo@hih.au.dk (B.K. Sovacool).

http://dx.doi.org/10.1016/j.erss.2016.08.013
2214-6296/

or configurations" and that these can involve "development of technical innovations (generation of novelties through new knowledge, science, artifacts, and industries) and their use (selection, adoption) in societal application domains." Transitions also include regulations, markets, infrastructures and cultural symbols. Therefore, transitions are multi-actor processes, involving interactions between firms, households, policymakers, social movements, scientific communities and special interest groups. They are radial shifts from one system to another and such radicalism can be understood not only as shifts in time but also as shifts in scope: radical innovations can be disruptive and also lead to Schumpeter's "creative destruction."

Geels [14], more analytically, suggests that transitions involve changes in three interrelated dimensions: 1) the tangible elements of socio-technical systems (technologies, markets, consumption patterns, infrastructures, production facilities, supply and distribution chains), 2) actors and social networks (new strategies, investment patterns, change coalitions, capabilities), and 3) socio-technical regimes (formal rules and intangible institutions like norms, mindsets, belief systems, discourses, views on normality, social practices). So, the two academic approaches to energy transitions noted above partly stems from scholars focusing on different dimensions of a complex phenomenon. Grubler et al., Fouquet, and Smil focus on tangible elements and a sub-set of actors (mainly firms and consumers), whereas Kern and Rogge and Bromley (and Fouquet to some extent) focus on a wider set of actors and changes in institutions and regimes, which may shape identities, preferences and interpretations of actors, as well as markets.

This distinction helps explain their different views on the temporality of transitions. Grubler et al. and Smil see transitions as slow because of various techno-economic rationales: 1) it takes a long time to build large (infrastructural) systems, 2) new technologies and systems only gradually improve their competitiveness (via learning curves and scale economies), which leads to gradual replacement of incumbent systems in existing markets, and 3) existing technologies and systems will disappear slowly, because of sunk investments and economic logics to milk assets until they are written off. Kern and Rogge and Bromley see low-carbon transitions as potentially faster than historical transitions, because political will and a societal sense of urgency may lead to policies that change markets and selection environments (e.g. carbon tax, cap-and-trade, feed-in-tariffs, renewables obligations, contracts-for-difference) or even phase-out technologies before they are written off (e.g. the German nuclear phase-out, a ban on incandescent light bulbs, plans to replace and retire coal). So, the core of their argument is that politics may trump economics, particularly if supported by wider publics, a sense of urgency and legitimacy about problems, and cultural discourses that frame existing technologies as undesirable or dangerous and low-carbon technologies as creating jobs, improving quality of life or protecting nature.

The distinctions are also important to reflect on the implications for future low-carbon transitions, which was Sovacool's background motivation. Arguably, there are two important differences between historical and future low-carbon transitions. First, historical transitions were more 'opportunity' driven, whereas low-carbon transitions are more 'problem-driven'. Since this problem involves a collective good (the climate), policymakers and civil society will have to play important role to overcome free rider problems and internalize negative externalities. Second, in evolutionary terms, historical transitions were more about developing 'variations' (technologies), whereas low-carbon transitions will also be about adjusting 'selection environments' (via policies, regulations, incentives that shape markets). Both differences imply that socio-institutional processes will be crucial in low-carbon transitions besides techno-economic dimensions. Grubler et al. and Smil insufficiently recognize these differences, which limits the generalizability of their historical findings. We therefore concur with Kern and Rogge [5], who write that "while history is important in order to understand the dynamics of transitions, the pace of historic transitions is only partly a good guide to the future." They also note that dynamic feedback mechanisms may be different going forward and that the sheer urgency and wicked nature of climate change as a global problem may motivate action. The old adage "necessity is the mother of invention" comes to mind.

3. Transition speed and different (layers of) energy systems

With regard to tangible elements of energy systems, it may be useful to distinguish different 'parts' or 'layers' and investigate the implications for transition speed. Although they overlap to some extent, we suggest that one can break down transitions into subsystems across at least four layers.

1. The *extractive industries* most related to energy production encompass the mining of coal and the production of crude oil and natural gas, as well as (occasionally) the mining and processing of uranium. The extractive industries also provide the material needs—copper, rare earth elements, alumina, and others—needed to manufacture power plants, cars, transmission lines, and other electronic devices, sometimes called "critical materials." In essence, the need for all of these resources reminds us that "energy" must be mined, leached, processed, and turned into usable products that can be bought and sold.
2. *Systems of national conversion and supply* are more frequently discussed, and the articles in the Debate are no exception. These involve the networks of power plants, oil and gas refineries and petrol stations, and other infrastructures that convert extractive resources—including fossil fuels as well as alternatives—into electricity, heat, mechanical energy, or liquid fuel.
3. *Prime movers* (or end-use technologies) are "energy converters able to produce kinetic mechanical energy in forms suitable for human uses" Smil [15]: 6. That is a fancy way of saying they are the technology that converts primary and secondary fuels into useful and usable energy services. Without prime movers, all of the dazzling technological advances human civilization has made over the past millennia would remain nothing more than unrealized concepts. Human muscles are the classic prime movers; those muscles enabled us to hunt, gather, and farm. The first mechanical prime movers were simple sails, water wheels, and windmills; the industrial revolution had its steam engines and turbines; the modern area has internal combustion engines, jet turbines, compact florescent light bulbs, and household electric appliances [16].
4. Energy resources and prime movers need *delivery infrastructure* to connect them, and while such transportation and distribution systems are breathtakingly variegated, the three most prominent are pipelines, tankers, and electric transmission and distribution lines. Taken together, this infrastructure occupies a substantial chunk of land, with one assessment estimating that roughly 30,000 km^2—the size of Belgium—are currently dedicated exclusively to supporting the oil, gas, coal, and electricity industries [15].

Now, Grubler et al. [3] and Smil [4] suggest that the creation of new delivery infrastructure systems (e.g. electricity grids, highway systems) is almost always a slow decades-long process, because of their capital intensity, geographical spread, and complexity, a finding that resonates with large technical system research [17,18]. We agree with this, but note there may be exceptions, where opportunities, political will and business support may accelerate dynamics. One example is the creation of a national gas infrastructure in the