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Transition Strategies

Increasing the speed, scope, and level of decarbonization for meeting the Net-zero 2050 challenge

Implications for sustainability transitions research

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Abstract

This viewpoint identifies three interrelated transition imperatives to achieve net-zero emissions by 2050 – increasing the speed, scope and level of decarbonization. First, the urgency of climate action places temporality and radically accelerated sociotechnical change at the heart of the net-zero 2050 challenge. Second, the net-zero challenge implies a broadening of decarbonization efforts from the usual focus on electricity and transport to all sectors of the economy and a need for thinking across multiple sectors. Third, increasing levels of decarbonization necessitates widespread and rapid diffusion of low-carbon solutions with limited time for experimentation and deliberation. Interactions between these imperatives create research challenges related to time frame tensions, tipping points, sector couplings, multi-sector technologies and massive upscaling.

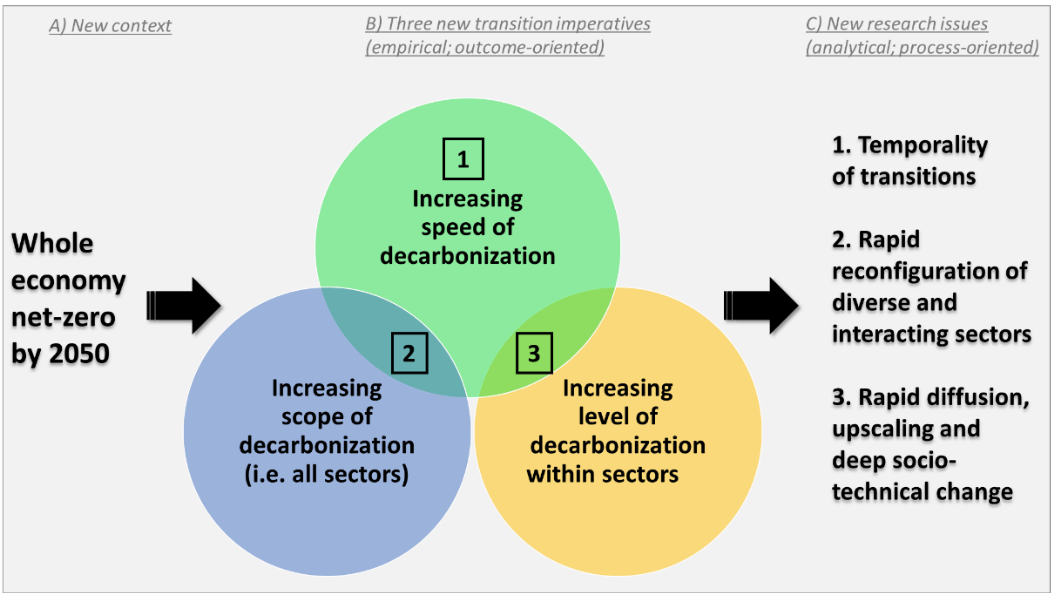
Keywords

Temporality; multi-sector transitions; multi-sector technology; diffusion; upscaling

1 A new context for transition studies

The next decades of energy and climate policy will pivot around the goal of achieving net-zero emissions by 2050 which aligns with limiting the global temperature rise to 1.5 °C (IEA, 2021). This new context generates new interrelated transition imperatives. First, the 2050 'climate-crisis deadline' requires that these decarbonization efforts happen at unprecedented speed. Second, it requires a broadening the scope of decarbonization efforts to the whole economy involving new types of sectors. Third, it requires increasing the level of decarbonization efforts to reach net-zero in all sectors. These imperatives are partly acknowledged in the transitions literature, but often as singular topics. We identify a selected set of research challenges emerging from their *interaction* that merit particular attention (see figure 1). In this perspective, we seek to articulate the sociotechnical tensions arising from these interactions as a first step towards a broader research agenda. As a consequence, we highlight the centrality of historically unparalleled yet purposeful acceleration of sociotechnical change as it generates entirely new challenges to transition research.

FIGURE 1: GRAPHICAL SUMMARY



2 Exploring temporality of transitions

The urgency of climate action places radically accelerated sociotechnical change at the heart of the net-zero 2050 challenge. The time left for experimentation may be rapidly coming to an end in the face of the imminent threat to planetary well-being from climate warming. Transition scholars have started to analyse the temporality of transitions including distinguishing layers of time (Raven et al., 2012), the influence of technology characteristics on the pace of transitions (Grubler et al., 2016; Sovacool, 2016), and political *acceleration* of transitions (Roberts & Geels, 2019). The discomforting insight from this work is that most change is slow and that rapid change is possible but rare. There is thus need to better understand purposeful shifts from slow to rapid change. We point to two potential inroads for this.

The concept of time frame tensions can be a useful tool in this regard. Actor strategies, institutions, and policies implicitly or explicitly work according to particular times frames, i.e., when and how fast something should happen (Bansal & DesJardine, 2014; Slawinski & Bansal, 2012). For example, many organizations need to internalize the ‘climate-crisis time frame’ into their organizational time frame. Also, institutions embody time frames that can be more or less aligned with ‘climate-crisis time’. Explicating time frames of actors and structures can be useful for understanding how these transform as well as whether and how policy can support such processes.

We also need to better understand the conditions and drivers of accelerated change. The literatures on positive feedbacks and tipping points may be useful to improve our understanding of how series of small steps can accumulate and prepare the ground for cascades of tipping points and rapid strategic reorientations of actors (Sharpe & Lenton, 2021; Smith et al., 2020), which may accelerate niche breakthroughs and regime destabilization.

3 Rapid reconfiguration of diverse and interacting sectors

The increasing scope of decarbonization efforts implies that transition researchers should look beyond electricity and transportation to consider neglected sectors such as mining, chemicals, and cement as well as aviation, shipping, and ICT. Although we know that the sociotechnical configuration of sectors differ for instance in terms of their institutional setup (Fuenfschilling & Truffer, 2014; Geels, 2004), there is currently limited theorizing about how sectors systematically differ (Fuenfschilling & Truffer, 2014; Kanger, 2020; Marín & Goya, 2021) and what this implies for the *temporality* of transition dynamics.

Sectors are typically interlinked in many different ways through material and resource flows, values and organizing principles (Andersen & Markard, 2020; Schot & Kanger, 2018). The net-zero challenge will involve a fundamental reconfiguration of these inter-sectoral linkages inter alia exemplified through the push for widespread electrification or use of hydrogen while cutting linkages to fossil fuel suppliers. Any net-zero strategy should therefore reflect thinking across multiple sectors from the outset.

Due to sector differences, reconfiguration of cross-sectoral couplings are often characterized by tensions between e.g. contrasting institutional logics or actor interests (Raven, 2007; Rosenbloom, 2019; Smink et al., 2015). For transition scholars, it is especially relevant to investigate interactions and co-evolution between sectoral transitions and how these can have accelerating effects (Andersen et al., 2020; Papachristos et al., 2013; Rosenbloom, 2020). Net-zero also implies that some solutions—e.g. CCS, ammonia, and hydrogen—may play vital roles in multiple sector transitions. How such multi-sectoral technologies can *rapidly* develop and diffuse also warrants more attention.

Transition scholars need a better understanding of the temporality of multi-sectoral interactions in transition processes and especially to grasp whether and how inter-sectoral tensions can be mitigated or even anticipated and avoided through policy measures to accelerate decarbonization.

4 Rapid diffusion, upscaling and deep sociotechnical change

A key aspect of achieving net-zero decarbonization in individual sectors is wide diffusion of low-carbon solutions (Markard et al., 2020). While niche experimentation is extensively studied, widespread and rapid diffusion of low-carbon solutions has received less attention in transition studies (Geels & Johnson, 2018). For example, innovation management scholars posit that socio-political barriers are mainly important in the formative phase of innovations, while diffusion is characterized by a self-propelling momentum of new solutions via positive feedbacks (Rogers, 2003; Tushman & Rosenkopf, 1992). However, as transitions advance there are also accumulating tensions that slow down or halt diffusion (Löhr & Mattes, 2020; Skjølsvold & Coenen, 2021).

One source of tensions arise from diffusion of new zero-emission solutions within a sector. Wide diffusion of a new set of solutions bringing a sector to zero-emissions may involve a deepening of sociotechnical change understood as involving not just technological substitutions but also major changes in other elements as user life styles, values, social practices, business models, and even sector architectures that often disrupt both companies' business models and user practices (Geels et al., 2017). Tensions can furthermore appear in relation to loss of jobs and even livelihoods associated with declining solutions (Rogge & Johnstone, 2017). Such tensions have historically been mitigated through experimentation, participatory democratic discussion and stakeholder negotiations in learning-by-doing implementation processes. Still, the urgency of the climate crisis suggests that there may not be enough time for such processes to unfold in the same way as before. Research on how such tensions emerge and are socially negotiated with *attention to temporality* is thus itself an urgent task for transition scholarship.

Another source of tensions arise from upscaling production of new zero-emission solutions associated with widespread diffusion of low-emission solutions (Mäkitie et al., 2020). Such massive upscaling of manufacturing and installation capacity involve innovations, expansion and reorganization of emerging (global) value chains (Ponte et al., 2019). A potential bottleneck for value chain expansion is inability of raw material sectors to grow rapidly which may influence the pace and direction (e.g. towards less resource-intensive solutions or some based on non-conflict minerals) of transitions (Andersen et al., 2018; Bazilian, 2018). Expanding mining of particular minerals can moreover create tensions with several sustainability dimensions in source regions including pollution and poor working conditions (Marín & Goya, 2021; Sovacool et al., 2020). As a consequence, recycling of critical materials is likely to become central for rapid transitions, increasing the importance of the waste sector (Skeete et al., 2020). Future transitions research should therefore further investigate how global value chains across multiple and diverse sectors can be upscaled *rapidly and sustainably*.

Regardless of source, the tensions we can expect on the road towards net-zero manifest as interdependencies between the different sustainable development goals (SDGs) such as between decarbonization and poverty alleviation, nature conservation, and decent work (Fuso Nerini et al., 2018; Linnerud et al., 2021).

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