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Are rapid and inclusive energy and climate transitions oxymorons? Towards principles of responsible acceleration

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ABSTRACT

Building from two strands of literature within “*Sociotechnical agendas: Reviewing future directions for energy and climate research*”, this perspective piece seeks to open a discussion about how to responsibly accelerate transitions. First, we identify a managerial literature on how innovation and diffusion can be accelerated, which focuses on deliberation with consensus-oriented ambitions. Second, is a set of perspectives that highlights unevenness, and therefore seeks to radically expand climate and energy democracy by promoting new forms of participatory practices. There are few contact points between these literatures. We argue that this can be explained by tensions and paradoxes that accompany accelerated transitions. These paradoxes cannot easily be resolved. We discuss how accelerated social and technological change poses challenges to inclusive and participatory transitions. Further, we discuss how rapid transitions tends to contribute to conflicts between core and peripheral sites. Thus, transitions are not only affected by societal conditions, but also contribute to co-producing social order, including the many forms of social turmoil currently experienced. Such insight places greater responsibilities on transition scholars, especially from reflexive disciplines such as STS and geography. We conclude by discussing how this responsibility could translate into situating climate and energy transition scholarship in broader debates about future socio-technical orders, and sketch three principles of responsible acceleration: a) Moving towards a broad epistemic basis for producing and assessing transition policies and strategies, b) Nurturing polycentrism for rapid climate and energy transitions, and c) Developing polytemporal strategies for transition.

1. Introduction

Scholars that are interested in change, innovation, and transition, live in interesting times. Globally, we face a double challenge of increasing environmental degradation and socio-economic inequality [1,2], combined with social, cultural and political polarization within and between countries and social groups [3]. In Europe, these developments have paved the way for populist parties to take seat in many governments, sometimes influencing climate policies and strategies [4]. Adding to this narrative of turmoil, we are currently amid a global pandemic, with unknown but likely critical impacts on energy and climate transition pathways [5].

All of this serves as a circumstantial backdrop for the recently published Sociotechnical agendas [6], which takes stock of the ways that Science and Technology Studies (STS) have engaged with the nexus of energy and climate issues. It seeks to build from this to establish a set of

future research agendas, or new ways that STS can contribute to energy social science. It provides a broad overview, showcasing 15 different perspectives from an impressive list of contributors. Through this, it illustrates that STS has important roles to play in both understanding and enacting climate and energy transition, by providing useful entry-points to the presented perspectives. Through an exercise of triangulation in terms of identifying common future research themes (“thinking across”), the piece also suggests some ways that the 15 perspectives can be linked, mainly to strengthen the robustness of empirical or theoretical insights from individual studies. The outcome is a call for less silo-oriented dogmatism, more diversity and more cross-fertilization both within STS-oriented energy social science, and between STS and other nodes of research and practice.

While it is difficult to disagree with this call for openness, our interest here is to explore implicit tensions and lack of contact points between some of the presented perspectives in the sociotechnical agendas [6]. We

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will argue that these tensions do not only arise as symptoms of introspective academic dogmatism, but also reflect important underlying contradictions or paradoxes that arise from processes of transformation or accelerated transitions. These tensions are not yet well understood nor reflected in the literature on climate and energy transitions.

First, we take an interest in the temporal aspects of transitions. We explore the relationship between a push to increase the pace of socio-technical change, and our collective ability to enact such change inclusively, in participatory and democratic ways. Here, we find inspiration in literature that problematizes the relationship between accelerated social and technological processes and participatory governance [7–9]. Second, we discuss spatial aspects of the transition. Here, we focus on the relationship between activities within cores and peripheries, where sustainability transitions sometimes strengthen cores at the expense of peripheries [10,11].

These two discussions along temporal and spatial dimensions of transitions illustrate how sustainability transitions are not only influenced by contemporary societal turmoil. Rather, they contribute to producing such conditions. This is not well-reflected in the socio-technical agendas [6], but re-iterates STS-insights highlighting that technoscientific development and social order is co-produced [12,13]. This move elevates the importance of sustainability transitions as a key process of broad societal change. Climate and energy transitions reach beyond decarbonizing socio-technical systems and sectors, they entail carving out new societal conditions. In light of this, we argue that urgency should be combined with reflexivity and call for a new focus on responsible acceleration of transitions. STS, geography, and related social-science perspectives can play key roles in advancing our understanding of what that might entail.

2. Two key challenges identified in the sociotechnical agendas: accelerating transitions and advancing radical energy democracy

Some sections of the sociotechnical agendas [6] primarily discusses socio-technical transitions as innovation journeys (e.g. sections 3.1, 4.2). Building on insights from the multi-level perspective [14] and related frameworks [15], these discussions flag diffusion and acceleration of low carbon innovations, along with ‘whole-systems’ thinking as central themes. Here, the socio-technical agendas [6] aligns with much literature on sustainability transitions, which sees understanding the dynamics of accelerating transitions as a central challenge (e.g. [16–18]). This focus has been re-iterated in broader attempts to carve out agendas for future work within energy and climate social science and humanities (e.g. [19,20]).

From such literature, the sociotechnical agendas [6] identify several drivers of accelerated transitions. Some of these are understood as landscape developments, e.g. external shocks like natural disasters and nuclear accidents [21], or broad stroke historical developments such as urbanization [22]. The main bulk of work flagged to accelerate transitions, however, occurs within and around niches. Acceleration, here, is highlighted to entail a) expanding coalitions, b) producing positive discourses and visions that appeal to mass publics, c) rapid technology development, and d) major policy changes that alter technology selection environments. These niche-related themes also dominate in research on the geography of sustainability transitions [23]. On a regime level, these developments should be combined with work to destabilize dominant fossil intensive regimes [6].

While there are important nuances in this literature which lie beyond what we can address in this perspective piece, key traits highlighted in the work on accelerating transitions involves creating shared social worlds through purposeful and steered expansion of networks and coalitions that share interests, as well as shared visions with mass appeal. This is reflected in the socio-technical agendas [6] sections on transformative innovation policy [24], which highlights “deliberate acceleration” and “coalition building” as central elements of stimulating

intensified change (See [6], section 4.1). In sum, this literature can be described as promoting a managerial perspective on transitions, with a focus on deliberation with consensus-oriented ambitions.

Another set of perspectives within the Sociotechnical agendas [6], shares few contact points with the above discussion, and can be read as an implicit criticism of its line of reasoning. The sections on power, gender, and justice (3.3) and public engagement and deliberation (5.1) are examples of this, which echoes increasing attention to such issues in broader scholarly debates about transitions (e.g. [25,26]). Rather than focus on mass publics and shared interest, the perspectives raised in these sections highlight radical differences of interests amongst social groups across territories, genders, class, and race. On the one hand, these sections point out the unequal positionalities that groups and actors have in building up dominant and carbon intensive socio-technical systems, with resulting vested interest amongst elites favoring stability over change (see e.g. [27]). On the other hand, there is an interest in understanding which groups take the lead in advancing new socio-technical systems, who are excluded from such processes, and in turn, analyzing broadly how socio-technical transitions might lead to inequality and reinforcing existing power structures. Building on such insights, work to ‘manage’ transitions, has been noted to undermine “*democratic, accountable politics around conflicting knowledges, contending interests and contested normativities*” [28].

As a result of such concerns, these sections call for diversifying climate and energy leadership, as well as for producing new and more complex modes of public participation in transitions. The focus is not on ‘innovation journeys’ per se but rather on how dominant modes of participation guide innovation journeys and can result in social injustice and democratic deficiency. These sections can be read together as calling for a radical expansion of energy democracy, echoing a long-standing STS ethos of finding new ways to mobilize publics and citizens in scientific practice and innovation (e.g. [29–31]). Just as the focus on acceleration, the focus on justice and diversity brings sociotechnical agendas [6] in close dialogue with other recent attempts to show which directions future research should take. Ethics, justice and participatory aspects of energy and climate transitions are prominent elements of such agendas [16,19,32], alongside the earlier discussed focus on acceleration.

3. Exploring the frictions between acceleration and inclusive participation

With some notable exceptions [33], discussions on accelerating transitions and on making them more inclusive and democratic are relatively separate streams of academic literature. The introductory passages to the socio-technical agendas [6] provides an important clue to why that might be. Through contrasting radio diffusion rates with Facebook diffusion rates, and observing increasing rates of vocational shifts over the last generations, those passages notes how the pace of socio-technical change has accelerated steadily in contemporary knowledge-based societies and learning economies for a long time (see also [34]).

This observation opens potential links to other literatures that are concerned with general processes of acceleration in late modernity, which are not often mobilized in discussions about sustainability transitions. Noting that the relationship between humans and their environments have never changed more quickly than during the last century, scholars trying to understand the conditions of the Anthropocene tends to see the same period as “the great acceleration” (e.g. [35,36]). Social scientists have also observed more general patterns of acceleration over the last century. A notable example is Hartmut Rosa’s efforts over the last 25 years to develop a sociologically rooted theory of modernity based on observations of increased social acceleration (e.g. [7,8]). Building from classical social theorists (e.g. Durkheim, Weber, Simmel and Marx), Rosa argues that understanding acceleration is *the* key challenge for contemporary social theorists. He argues that late

modernity is characterized by three types of acceleration:

- *Technological-technical acceleration*, characterized by rapid shifts in material structures of societies, accompanied by quicker processes of “organization, decision, administration and control” [7p. 74].
- *Acceleration of social change*, characterized by an increasing tempo in changes of practices and action orientation, but also in changes of patterns of relationships and associational structures.
- *Acceleration of the pace of life*, which is characterized as “an increase of episodes of action and/or experience per unit of time as a result of a scarcity of time resources” [7p. 121].

Another strand of literature concerned with the conditions and consequences of rapid social change can be found within critical policy studies and geography. Here, some scholars have diagnosed much contemporary policy making as “fast policy” [9]. These literatures provide important insights about how to understand acceleration processes, and the links between acceleration and issues such as democratic decision making. We cannot do justice to this literature in this perspective piece, so we will settle for sketching two points that can help us understand the frictions and lack of synergies between literatures on accelerated climate and energy transitions, and inclusive, participatory and democratic transitions on the other.

The first point is a general concern for the relationship between democracy and acceleration. Hartmut Rosa [7,8], notes that in early modernity, the establishment of democratic processes within modern states were important accelerators of social reform and technological processes. The establishment of democratic political systems, he argues, shortened the time horizon of political decision making from a lifetime which had been the rule under traditional monarchies to an election cycle. As modern states were built, democracies were steadily expanded to encompass different scales of governance and more social groups. This happened in tandem with the expansion of rationalizing bureaucracies that served as to standardize and enable quick and predictable decisions based on stable rules.

Following scholarship on participatory processes and the democratization of technoscientific work (e.g. [37,38]), Rosa’s portrait of democracy would be too essentialist to serve as an empirical description of the diverse forms of participatory practices that interests us [39]. Energy- and climate democracies would not only be formal modes of political governance, but a wide multiplicity of processes and practices through which various publics could participate through formal political instruments such as elections [40], various forms of dialogue exercises [41], citizen science [42], or material devices [43], just to name some examples.

While our interests are broader, Rosa’s argument is of particular interest to our focus on acceleration, as he notes that in contemporary societies, democratic processes and ideals are no longer accelerators but brakes. As the pace of social processes and technological innovations have accelerated, we have seen increased social and technological complexity across societal domains which has resulted in a demand for even more frequent decision-making in non-standardized domains. Thus, time resources shrink, while ever-increasing complexity creates a demand for constant decisions. Under these conditions, scholars of social acceleration tend to highlight that democracy often loses. As Scheuerman ([44], p. xiv) highlights: “*a high speed society places a premium on rapid-fire political [practices] [...] that often promotes executive-centered government*”. Or as Rosa notes [7,8], decisions across increasing numbers of societal domains are relocated from democratic and political domains (e.g. parliaments and municipal councils) to faster systems such as the legal system, markets, and the private companies that populate them. Within the climate change domain, this has become clearly visible over the last years, e.g. with value laden issues that have proven difficult to resolve through political deliberation increasingly finding their way into courtrooms (e.g. [45,46]).

Adding to this challenge, scholars who promote public forms of

participation to advance justice aspects around science and innovation, often seek to destabilize institutionalized modes of work to anticipate and mitigate injustice [47]. In some fields such processes have been described as “painfully self-reflexive” [48]. In discussions about energy transitions, the lack of enough time has been identified as delegitimizing participatory processes [49]. The crux of this argument is that participatory and democratic processes require time – a resource that in practice is often scarce. This also indicates that there is perhaps a tension here between expanding the scope of participatory processes and increasing the speed of socio-technical change that at its core is unresolvable. Such observations might point towards some limits of participatory processes to achieve rapid transition.

The second point we want to introduce concerns the conditions for producing shared social realities, which are central in many discussions on how to accelerate transitions, relying on mass appeal, growing networks of actors who share directionality and shared future visions. Hartmut Rosa [7,8] notes that while democratic decision making is often by-passed in an accelerating world, the same world is also characterized by an erosion of what he calls the cultural and socio-structural common ground for decision making. This erosion, he argues, is fueled by temporal processes of dynamization and de-synchronization, where social, scientific and cultural certainties are changed more frequently than in the past. Rosa refers to these developments as structural dynamization, which results in observable diversification also across the lifespans of citizens who increasingly often change vocation, family association, education, political and religious orientation. Further, companies more frequently change their core activities. A key point is that increased dynamization is accompanied by desynchronization, which signals that the speed of transformation and adaption differs across sectors, territories, social groups, and generations. As a collective consequence, it becomes increasingly difficult to formulate broadly shared visions for societal change, because we are increasingly inhabiting quite different socio-technical realities (see e.g. [50] for a related point on how inhabiting different worlds affect energy transitions).

The dynamics discussed over the last paragraphs mainly concern other phenomena than climate and energy transitions, but should resemble dynamics that are familiar to transition scholars. As energy and climate transitions accelerate, they entail introducing multiple, simultaneous and overlapping changes within and between many socio-technical systems in multi-scalar sectors such as energy, transport, industry and ICT, resulting in a series of complexities and new cross-sectoral challenges (e.g. [51,52]), as well as new inter-sectorial fields where new forms of innovation can emerge [53]. The new socio-technical configurations impact territories and social groups in different ways, which might result in social backlash [54–56]. Further, as the reach of new technologies expand, potential forms of epistemic contestation also increase, e.g. though controversies about the relative importance of different social, economic, and environmental goals and how to measure these on different scales [57]. Meanwhile, available time resources shrink steadily in what some have called a culture of climate deadline-ism [58].

Against this backdrop there is a need for more nuanced debates both about inclusivity and temporality in transitions, as well as work that do not take shared social realities for granted, but actively works to produce them around specific issues [59]. Within STS, much work has illustrated how our collective repertoire of understanding is not a mere reflection of a “world out there” but a mesh of matters of fact and matters of concern (e.g. [60]). Temporal considerations and spatial differentiation are precisely of this type (e.g. [10]), where there is a lack of value consensus [61].

Moving forward, a key challenge is to enable the constitution of broader temporal and spatial issues, which opens for broader public, scholarly and practical engagement with and participation in temporal and spatial questions of transitions. This would entail transcending ideals of embedding and implementing new technology as quickly as we can, especially given the strong relationship between increased speed

and environmental degradation [37]. Instead, more fundamental concerns with respect to the relationship between the speed of societal processes and sustainability, might lead us towards more actively thinking about the temporal and territorial politics of reaching sustainable societies. One consequence of this could be to ponder which societal processes require speeding up (e.g. the implementation of renewable energy), and which require slowing down (e.g. as indicated in calls for slow food, slow tourism, and slow cities) [62]. Hence, instead of calling for new policies that are geared towards accelerating technology-centered variants of transitions, we bring attention to the promise of poly-temporal strategies, where acceleration and deceleration or emergence and disassembly are two strategies that can be mobilized in pursuit of transition contingent on scale and place.

4. Tensions between core and periphery in accelerated transitions

The discussion above notes that as transitions accelerate, they might hamper inclusive and participatory modes of governance. This tension can, like the debate above, be related to overarching societal trends that polarize tensions between cores and peripheries. While the increased pace of technological innovation has contributed significantly to raising aggregate levels of well-being, prosperity and indeed expediting energy and climate transition pathways, its centrality in our contemporary societies and economies has also come at a price. While often overlooked in the past, there is growing scholarly interest in the dark sides of innovation and its potential noxious consequences (e.g. [63,64]), giving rise to new policy concepts such as responsible research and innovation [65,66]. Among others, this emerging scholarship recognizes how a continuous focus on novelty creation and innovation, is integral to growing socio-economic inequality and political polarization. These externalities of the knowledge economy are particularly manifested and compounded at the territorial level.

There is growing concern for what Andres Rodriguez-Pose [67] has called ‘the revenge of the places that don’t matter’ as a result of poor development prospects outside of those city-regions that are able to reap the fruits from the dynamism and innovativeness offered by agglomeration economies. Widening uneven territorial development, underpinned by accelerating pressures for innovation and economic dynamism, has given rise to a wave of political populism with strong place-based foundations and a particular geography of discontent related to local economic and industrial decline combined with lower employment and a less educated workforce [68]. This research suggests that this populist revolt through democracy’s ballot-box – at risk of leading towards an erosion of wider democratic principles and forms of decision-making, is creating increasingly untenable tensions between the urban cores driving change and innovation and the peripheral hinterlands that are challenged to adapt to these uneven development outcomes.

Work on the geography of transitions has offered important insights on the drivers of spatial differences of energy and climate transitions across countries, regions and cities. However, less attention has been given to the consequences of this unevenness and the potentially negative outcomes for specific communities and regions that find themselves on the losing end of the transition [10,11,69,70]. As transitions accelerate, engagement with the territorial consequences of uneven development, including decline, is increasingly pertinent [71]. Our understanding of transitions as (uneven) spatial processes has evolved significantly and gone far beyond its initial metaphorical accounts not the least due to an explicit inclusion of geographical terminology and concepts [72]. Despite some notable exceptions [73–75], patterns of core and periphery in transitions have been left relatively untouched despite their salience for questions concerning “just transitions,” and “who lives with the side effects” [76]. Unintentionally, this also led to sustainability transitions having developed an urban penchant [77] similar to research on the geography of innovation more generally [78].

We therefore argue that spatially distributed development in the multi-scalar geography of sustainability transitions should not only be acknowledged as an analytical matter of fact [79] but also as a matter of concern [80]. Creating territorial winners and losers in climate and energy transitions is inevitably also a political and ethical issue (sic). Here, sustainability transition research has often directed its attention to those places (and its actors, institutions and networks) that are on the generative side of climate and energy pathways, fixing its analytical gaze on those core countries, regions and cities that drive innovation and expedite transition. This bias has led to a primary interest with transition pathways in places rather than of places and is at risk of overlooking territorial tensions in terms of social sustainability. Rather than treating rising populism as an externality of sorts, climate and energy transition research would do well to open up for a more pluralistic perspective on transition governance that accounts for instability and rupture and that acknowledges a diversity of actors, identities, and opinions beyond simple dichotomies that only recognize drivers or barriers to transitions [11].

Similarly, it would be naïve to conflate core-periphery tensions with static labels of ‘winners’ and ‘losers’ in climate and energy transitions. Rather, notions of centrality and peripherality should be understood as relationally and dynamically constituted [81]. They are no givens but socially constructed and strategically governed through the collective agency of actors. With reference to Georg Simmel’s seminal work, Grabher [82] poignantly demonstrates how ‘fringe’ actors in peripheral territories can mobilize their self-chosen marginality and deliberate rejection of the mainstream to leverage creative agency and ‘to experiment with unconventional ideas because they are less constrained by role expectations or peer pressures and, therefore, more likely to champion dissenting ideas threatening the accepted canons of the field’ (p. 1786). This conceptualization of peripherality as a space for creativity and nurturing of radical ideas is strikingly similar to sustainability transitions research’s understanding of niche-level innovation. However, to balance an overly heroic account of peripherality we should also be reminded that (the shaping of) cores and peripheries involve political-economic processes of subordination, struggle, exploitation and value extraction [83]. Tensions between core and periphery are most likely to grow as climate and energy transition pathways unfold and accelerate across space, creating both contested and creative points of friction in industrial dynamics, discourse narratives and resource flows across multiple sites and territories in transition.

In our perspective we argue that accelerated but just transitions require responsible and balanced territorial governance of climate and energy transition pathways. This would entail working towards the recognition and empowerment not only of urban and commercial centers, but of the multitude of other sites which contain human, natural and economic resources which can be mobilized through poly-centric networks in transition endeavors (e.g. [84]). Further, attention and awareness of the pertinence of core-periphery tensions and, for sustainability transition research specifically, a greater engagement with the fate(s) of industries, workers, communities and other groups that are disadvantaged by and/or excluded from decision-making processes in sustainability transitions is warranted. This goes beyond immediate concerns for phasing-out and exnovation of carbon incumbency. Table 1 summarizes key points from the above discussions.

5. Concluding discussion: towards epistemic, temporal and spatial principles of responsible acceleration?

The sociotechnical agendas [6] illustrates that academic communities within and around STS are deeply engaged both with working to understand how to accelerate climate and energy transitions, and, trying to understand what expanding energy and climate democracy might entail. In our perspective piece we have engaged with these themes by taking a step back to discuss more broadly how this divide can be interpreted as the result of tensions, or dilemmas that accompany

Table 1
Two dilemmas of accelerated transitions.

Dilemma of accelerated transition	Expressions in literature	Ways forward
High-speed socio-technical transformation and inclusive change are not always compatible	Separate research agendas on accelerated climate and energy transitions and inclusivity, participation and democratization	Broaden debate from asking how to accelerate to seek broader polytemporal strategies. Recognize limitations of participation
High-speed socio-technical transformation exacerbates spatial unevenness and inequality	Bias towards focusing on global leadership and spatial cores driving transitions Lack of focus on consequences of spatial unevenness	Recognizing, analysing and empowering poly-centric governance Greater engagement with disadvantaged/excluded groups and places

climate and energy transitions. We have done so by discussing temporal and territorial aspects of transitions. Both discussions point towards a dual relationship where temporal and spatial conditions shape transitions, and are shaped by transitions. Our discussion suggests that energy and climate transitions might increase divides between cores and peripheries, and that dynamization and de-synchronization across temporalities and territories can sometimes increase social and economic inequalities, thereby feeding into a situation of social, economic, and political turmoil. Politically this also seems to be producing some paradoxes. On the one hand, populist parties that tend to down-play the threats of climate change gain traction [85], while on the other hand a growing number of young Europeans thinks that authoritarian states are better equipped than democratic states to respond to the climate crisis [86].

With this as a backdrop, we believe that scholars from fields such as STS and geography both have the tools and the responsibility to zoom out and to situate discussions about accelerating climate and energy transitions as part of a broader set of societal concerns which ultimately entails asking which kinds of societies we want to be part of co-producing. Building from a long tradition of STS in rejecting technological determinism [87,88], there is nothing inherent in accelerated innovation that leads to the sorts of issues we discuss in this perspective piece. Or, as argued by Marianna Mazzucato [89], we have been too preoccupied with the rate of innovation at the expense of its direction(s). Instead, the relational and constructivist perspectives of STS and geography suggests that these outcomes can be attributed to how acceleration is conducted, the actors, principles and logics that guide it. This also means, to paraphrase Steve Woolgar, that it could be done otherwise [90].

In what follows, we will suggest three ways that STS and geography can contribute to such an end, by engaging in debates that are broader than many of those proposed in the Sociotechnical agendas [6]. Our goal is not to undermine the overview provided there, but rather to use it as leverage for opening a discussion about epistemic, temporal, and spatial foundations for what we might call responsible acceleration.

1) *Moving towards a broad epistemic basis and inclusion when producing and assessing transition policy and governance strategies:* Textbook STS tends to emphasize that one of the first things that STS brought to our collective understanding of science and technology, was that technological and scientific outcomes are shaped also by forces external to scientific practice or external to innovation [91,92]. This is well-reflected in the strands of transitions research discussed in this perspective piece. On the one hand, work that seeks to understand acceleration often looks for clues about which societal conditions might enable high-speed innovation. On the other hand, scholars who seek to expand on energy democracy do this in part because they believe this will improve the outcomes of governance and innovation processes. Our discussion shows how processes of energy and climate transition also affects society in significant ways: acceleration affects our ability to

govern inclusively, and acceleration tends to produce different social realities that are anchored in temporal and spatial processes of differentiation. However, these phenomena are largely studied by different communities of researchers, or what Haas [93] called different epistemic communities, where the bridges between them are few.

To us, this signals that practices of responsible acceleration needs to build on analyses of the relationship between transitions and society which are what Valkenburg et al [94] have called epistemically inclusive. This suggests working not only to hear different social groups, but to involve and validate insights gleaned from potentially radically different epistemic positions, such as those that focus on the merit of speed vs. those that focus on the merit of inclusion. This should be done both when formulating transition strategies, and when developing indicators for evaluating their performance. This has also been called for in the transitions literature [95,96]. In itself, this move is unlikely to increase the speed of discrete technology implementation processes, but it is likely to increase long-term legitimacy, and reduce chances of surprising forms of contestation down the line.

2) *Nurturing polycentrism for rapid climate and energy transitions:* Our discussion highlights that transitions can contribute to social turmoil, e.g. through overpowering cores over peripheries, or by strengthening existing centers of governance and innovation at the expense of those left behind. In one of the few contributions that actively discusses the links between speed and plurality in transitions, Delina and Sovacool [33] proposes a dual response. First, they highlight the importance of cultivating plurality in knowledge production. Second, they suggest embracing principles of polycentrism in governance which also incorporates key aspects of just and humane transitions. We sympathize with this approach. Polycentrism entails the dispersion of decision-making capabilities and change agency. As an institutional structure it has been shown to be more likely than monocentric systems to produce self-organized, self-correcting and thus reflexive institutional change (e.g. [97]). To us, then, a key challenge is how to nurture this type of polycentrism during processes of rapid transformation, when many current trends rather point towards rapid transitions strengthening core centers while weakening peripheral ones. On the one hand, understanding these processes is an analytic challenge that is attuned to both the drivers and effects of spatial unevenness in sustainability transitions. On the other hand, this also points to the importance of developing new types of spatial-political strategies that actively nurtures a multitude of centres and acknowledges the multiplicities in which core and peripheries present and manifest themselves. For example, greater attention for transition and innovation in foundational economies – providing the local infrastructure for everyday lives through mundane but essential goods and services - may offer a welcome strategic development rationale that relaxes the scope for territorial competition between cities, regions and countries in climate and energy transitions and its conventions of locational tournaments and zero-sum games [98,99].

3) *Developing polytemporal understandings and strategies of transition:* A potential reading of the gap between the two types of literatures in the sociotechnical agendas [6] that we have not discussed yet is that they implicitly constitute polar opposite positions in a broader discussion about temporal aspects of transitions (i.e. that the solution to the sustainability challenge is either slow down our societies, or to speed up innovation). We do not believe this duality to be very fruitful. However, this reading contains what might be the seeds of a more nuanced approach to the temporality of transitions, where the politics of speed or what Paul Virilio has called chronopolitics (e.g. [100] for a discussion) plays an important role. Today, accelerating transitions tends to be discussed in terms of increasing the speed of innovation, or of speeding up the diffusion of green technologies or socio-technical systems. However, when probing concrete processes or concrete sites of transition, accelerating the innovation or diffusion of new technologies only constitutes one position in a broader repertoire of temporal strategies with bearings on sustainability. As an example of the opposite, Sarah Pink [101] discusses the slow city movement as an alternative approach

to regional sustainable development, and slow tourism has been noted as another example [102]. We don't want to advocate a collective slow-down of society, but rather call for a more active engagement with the different ways that temporality can be mobilized to achieve sustainability.

Triggered by the sociotechnical agendas [6], this perspective piece has called for, and suggested some gateways into the development of principles for responsible acceleration. Admittedly, it is beyond the scope of a perspective piece like this to translate these ideas into a practical operationalization at this point. Rather, we have pointed to some scholarly debates, as well as a series of examples from the practice field, where we believe that a more reflexive approach to accelerating transitions is warranted. We hope this piece will inspire further empirical and theoretical work in this direction.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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