The governance of sociotechnical transformations to sustainability

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The contribution makes use of a sociotechnical imaginaries (STI) framework to expose crucial but neglected governance issues in sociotechnical areas of key relevance to sustainability transformations such as energy systems. It explores how the STI concept can contribute to understanding transformations to sustainability (T2S) by illustrating their multidimensionality and temporality. It takes as its starting point a 'co-productionist' view illuminating how collective visions of desirable (or resisted) environmental futures limit or enable political imagination and the search for alternative transformative practices. It demonstrates how a focus on imaginaries can help reveal the complex multidimensionality of human needs, expectations, and uses of natural resources — and associated societal phenomena to enable T2S. By more explicitly addressing the technical as well as political and normative dimensions of T2S, this approach helps uncover the taken-for-granted assumptions that often shut down potentially promising imaginations, as well as makes visible alternate pathways and possible constitutional relationships in the triad of state and society.

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Introduction

This paper critically examines the political work done by sociotechnical imaginaries in transformations to sustainability (T2S). Drawing upon a review of the expanding literature, it outlines how imaginaries project visions of sustainable futures and thereby constitute and justify associated policy trajectories. The paper demonstrates how a focus on sociotechnical imaginaries can help explore potentialities and shortfalls of currently imagined T2S.[4] The underlying argument of the paper is that we need to be attentive to the politics at play in the collective imagining of sustainability transformations. Sociotechnical imaginaries are more than ideas. They bring material projects into being, justify them, and thereby open up or close down competing options for how to govern T2S.

Sustainability is perhaps the grandest sociotechnical imaginary of our time, as it projects both human and planetary futures into unlimited time. Jasanoff defines STIs as 'collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology' [1[··], p. 4]. Through this lens, many challenges in T2S can be linked to prevailing imaginaries of sustainability which preempt political contestation and consideration of alternative futures [2[··]].

The course and agenda of transition as well transformation research is often set by national and international expert bodies embracing a shared understanding of what is at stake. Authoritative expert groups, such as the Intergovernmental Panel on Climate Change (IPCC) and Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) [3–8], for example, have projected pathways to meet numerical, predefined targets (such as the Paris Climate Agreement, and the Sustainable Development Goals — SDGs). The IPCC has become the key institutional site where the imagining of sustainable climate futures is communally adopted and transformed into new collectively held and politically powerful visions of appropriate action. Case studies illustrate how the IPCC actively contributes to opening up and closing down the horizon of action in cognitive, spatial and temporal dimensions. The Panel selected pathways consistent with politically agreed temperature targets, thus closing down the possibility horizon to a narrow set of technical pathways all aimed at the same endpoint. However, a look beyond these expert-

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[4] For more information, see Belmont Forum project 'Governance of Sociotechnical Transformations' (GoST): www.gost-project.org.

articulated global pathways indicates that, in spite of bows to such seemingly universal notions as sustainable development, there are long-lasting sectoral differences, societal conflicts and cross-cultural variations in the practices of sustainability [9,10]. While transitions or transformations are defined as processes of fundamental, non-linear and systemic change, limited attention has been paid to the complex, multidimensional and temporal characteristics of underlying conflicts in the emerging T2S literature.

Scholarship in *science & technology studies* (STS) seeks to capture the multiple dimensionalities and temporalities of T2S [11]. The deliberately abstract nature of these two terms is essential in order to grasp the defining characteristics both of transformations themselves and of the ways in which they might best be enacted. 'Dimensionalities' refer to the constitutive features of the ontologies by means of which transformations are apprehended. 'Temporalities' refer to often invisible but typically highly formative assumptions about the dynamics of social change and the role of time itself. As such, each term is deeper in its epistemological grounding than is explicitly discussed in policy contexts, as well as more foundational in its explanations of divergent frameworks of understanding and more general in its application to contrasting empirical settings.

We argue that blindspots in T2S research can be remedied by adopting the co-productionist perspective that underlies the STI framework. This analytic approach provides a more complex interpretation of the relationships between science, technology and political power, one that stresses their essential interconnection. It enables the researcher to examine links between ways of representing and knowing a phenomenon on the one hand, and ways of acting upon it, so as to transform it, on the other [12]. Even those visions of plausible sustainable futures that are seemingly descriptive emerge as prescriptive in that they simultaneously bring forward visions of what counts as a desirable future and how it can be attained and governed [13]. The STI concept, in particular, offers an interpretive lens to explore underlying normative, but often inexplicit, rationales and justifications of policy choices for governing emerging technologies and distributing their risks and benefits. STI-framed research thus reflects on how imaginaries of sustainable futures may enable or limit the scope and spaces of political action for societal transformation, and hence either catalyse or delay the search for (alternative) transformative strategies [14].

The paper proceeds as follows: The section 'STI contributions to T2S' reviews the literature relevant to sociotechnical imaginaries and T2S, while also briefly summarizing the underlying theoretical approach. Building on this review, we draw out some key themes, findings and research gaps that emerged from the review. The section 'Conclusion: Rediscovering the politics of T2S' reflects in

conclusion on the implications of our study for the politics of T2S and future research more broadly.

STI contributions to T2S

This section reviews the literature relevant to STIs and asks what such research can tell us about the potential of this concept to produce innovative insights on T2S. STIs have only infrequently been applied to sustainable development [15,16], sustainability transitions [17,18] and transformation [19,20]. One of the most intensively researched topics within this field is STIs of energy transition, the focus of this brief paper [e.g. 21–23].

The first part of this section focuses on the multiple dimensionalities of T2S and the second elaborates on its temporality. Taken together, this approach helps us to understand how visions and enactments of alternative futures articulate divergent understandings of the common good and point toward prescriptions, or a kind of map of possibilities for what governance is needed or desired [7,24,25]. Imaginaries are less explicit and procedurally accountable than policy agendas; yet, unlike narratives, they more directly serve explanatory or justificatory purposes. As the ends of policy, they are futuristic: they project visions of what is good and worth attaining, or the reverse. The STI concept is used in order to capture the tensions between alternative visions and contingencies in policy choices, as well as discern the forms of power at work in articulating futures that 'ought' to be attained. Simultaneously, STIs raise the question whether or not, and to whom, the particular societal futures imaginable through technoscientific changes seem worth attaining.

Dimensionalities

The STI concept allows exploration of the multiple dimensionalities of T2S by stepping back from the assumption that descriptive and normative categories in which people make sense of transitions and sustainability are somehow equally self-evident to everybody involved, or describable in terms of universal understandings with respect to settled dimensions.

More specifically, 'dimensionality' as used in this paper refers to the complexities and ambiguities in assemblages of attributes and associated meanings that are understood to constitute states and processes implicated in what societies regard as transformation [26]. Crucially, the attributes associated with particular understandings of any specific imaginary or transformation may be 'polythetic'. This refers to variabilities that are much more complex and nuanced than can be described by simple 'monothetic' boundaries between categories [27] — distinguishing in more fine-grained ways between patterns of attributes reflecting various kinds of 'family resemblance' [28], multiplicity, overlap, nesting and interaction [29].

In contrast to much of the transition literature [30,31], the STI concept draws attention to the entanglement of the materiality of complex sociotechnical projects with the normative aspects of collective imaginations of states of society. It looks at environmental transformation, for example, not merely as changes in ways of using nature (e.g. agricultural, industrial, exploitative), but appreciating that associated notions of progress (for instance, 'transformation' according to definitions of prospective notionally desirable, or prior less desirable states) tend to map onto the world only in highly imperfect ways. There are typically many more salient dimensions to the phenomena in play than can be explicitly attended to in formal analysis in the non-interpretive social sciences. It is with attention to these subjective as well as objective considerations, that STI brings together work on the role of collective imagination [32–34] with work on technoscientific development [35–37].

Sociotechnical imaginaries differ importantly from narratives and discourses in the longstanding Foucauldian tradition because the latter usually focus on language, ideas and social practices whereas the former emphasizes purposiveness, action, and aspiration through materialization with technology [37]. In contrast to the transition literature, STIs do not focus only on the technical feasibility of realizing world-spanning pathways to technological endpoints such as a low-carbon future [38]. More multidimensional entanglements occur, for example, in the collective framing of risks, their long-term as well as short-term nature, their implications for vulnerability and resilience, as well as responsibilities for and ownership of those risks and benefits along disparate technological pathways linked to sustainable futures.

Policy focus
Imaginaries not only reflect and reconfigure actors' sense of the rightness of action but also their sense of possible spaces and forms of action and their own agency, or lack thereof, in the future [1**,15]. STIs therefore serve as modes of societal self-organization that contribute to opening up or closing down possible horizons of future action [24], and thus shape the channels within which political actors make decisions [39,40], or make particular choices more or less plausible.

Controversy
Research on fictional expectations indicates that visions of the future can have important distributional consequences, making them a legitimate object of political challenge, debate, and choice [41**]. By providing legitimacy for some, but not all, political goals, imaginations of the future become a terrain of struggle over essentially conflicting expectations concerning long-term developments such as T2S.

Closure
A core argument in the STS literature is that knowledge production is a process in which some observations are selectively recognized as real and/or relevant, while others are not and therefore do not need to be accounted for. As such, knowledge garnered by dominant institutions can paradoxically be an impediment to social action through the silencing of other relevant forms of knowing and through the production of particular forms of non-knowledge [13]. Studies on the safety of nuclear power [42] as well as Carbon Dioxide Removal technologies [7] indicate a need to look critically at taken-for-granted choices and underlying assumptions in expert projections of the future and to render them open to debate, so that tomorrow's visions of climate futures — such as linear optimization logics — are not curtailed by the narrow views we see in the world today. Technological systems are built at all levels upon taken-for-granted assumptions that necessarily shut down alternative imaginations [43], some of which may be more generative for T2S.

It is with reference to such concerns that the STI framework provides a useful lens for interrogating dominant national assumptions and understandings concerning T2S. Such comparison should not be taken as reifying national positions, since our approach presumes that STIs are multiple within any complex social structure, such as a nation state. Nevertheless a table such as the one below points toward the competing dimensionalities at play in four advanced industrial nations, each of which has grappled with the desirability of nuclear power in the face of safety concerns, social mobilization, the vision of a low-carbon future, and the rising global pressure for T2S:

Countries/STI Elements	US	Germany	India	UK
Framing Risks	Runaway accidents; catastrophic damage	Irresponsible and catastrophic damage	National security and energy self-sufficiency	Acceptability of cost-benefit balance
Policy Focus	Controlling radiation	Increasing transparency	Increased capacity to serve national security, energy self-sufficiency	Maintaining military-relevant national 'nuclear industrial base'
Controversy	Quantitative expert risk assessments	Inaccessible expert risk assessments	Environmental and health damage	Siting and growing levels of necessary public subsidies
Closure	Court cases; nationalization	Political mobilization; legislation	Court cases; nationalization	Cabinet-level engineering of policy structures

Sources: Authors.

Temporality

'Temporality' refers to the many different ways in which change can unfold over time [44], including not only continuous 'monotonic' processes of change at variously linear or nonlinear rates in a particular direction, but also 'non-monotonic' or rhythm-like dynamics and movements in multiple dimensions [45,46], with room for surprises, disruptions, shocks, and regress as well as progress. The greater a society's capacity to apprehend 'polythetic' complexities across dimensions, the deeper its likely ability to appreciate the importance of what may often be more undulating [47], messy [48] and turbulent temporalities [49] that can be so central to sustainability [50].

Nationally salient choices and variations between alternative ways of achieving T2S can be seen as playing out distinctive imaginaries of what counts as a desirable future [51], as well as what it means to transform in a sustainable way [52]. Analysing these different choices steers our attention to the political aspects of imagining sustainable futures. Most studies to date demonstrate that, if framed in ways that are monotonic and monothetic, as technocratic expert framings often are, the time frame, scope and dimensions of alternative and diverse imaginations are all correspondingly reduced [53–59], as are the opportunities for democratic deliberation. The results are then often criticized for neglecting the political dimensions of transformation, in the deeply contested history of nuclear energy, for example [60••]. A similar criticism has been levelled at the sustainability transition field, where research is used to inform policy without sufficiently accounting for issues of power, politics, and directionality — where directionality refers to the multiple dimensions along which change can unfold [61–65].

For instance, there is the striking recent history of contrast between the zero carbon electricity strategy underpinning the UK *nuclear renaissance* [66] and the German renewables-based *Energiewende* [67]. On the face of it, these reflect contrasting features of industrial infrastructures, political cultures and associated imaginaries of constitutional governance in these two settings [68]. There certainly are many salient axes for distinctions [38], but these differences might be considered too superficial to satisfactorily explain why two such closely comparable countries — federated liberal democracies committed to constitutional governance and the rule of law — should adopt national energy transition strategies that are so starkly different even on a worldwide stage [22]. Conventional explanations in terms of neatly categorised 'monothetic' contrasts between notionally national-level categories of energy 'regime' [69], 'sociotechnical system' [70] or their embedded 'policy networks' [71] elite 'expectations' [72], driving political

'visions' [73] or policy 'transition pathways' [74], may risk seriously simplifying the dynamics of national divergences [75].

Simple pictures of two categorically diverging 'monotonic' 'sociotechnical trajectories', may conceal more complex struggles between contending concurrent orientations toward change [47]. What STis help disclose are not so much set-piece contrasts between supposedly nation-specific factors that explain moments of binary choice (e.g. pro-nuclear or anti-nuclear), but rather the imaginative repertoires from which societies construct possible pathways into the *terra incognita* of the future. Understandings that are not fully captured by conventional disciplinary commitments in the study of 'sustainability transitions' [76] may instead see specific drivers bearing in from outside the frequently cited and notionally stable formations of 'regimes', 'infrastructures', 'networks', 'interests', or 'economies' [75]. Rather than resting on supposedly measurable differences between what are actually quite comparable plural formations in each national setting, the striking contemporary national contrasts between UK and German energy strategies may owe more to deeper divergences in the structure of mutual expectations and obligations between state and society and society and technology, producing relational patterns that transcend conventional causal analysis and give meaning and value to sociotechnical relations [22].

The transformative power of imagining the future

In agreeing to opt for any vision of a future world, imagination can serve as a potent political resource. Work in the sociology of futures explains how imaginations of the future influence social change [77••,78,79]. Beckert speaks of 'fictional expectations' which generate social activity and hence are performative in the sense described in STS. Actors act *as if* these imagined futures are likely to come about, thereby bringing them into being. These fictions offer incentives for converting purely speculative visions into politically powerful and actionable plans for constituting futures [80]. In the emerging transition and transformation literature, the performativity of visions is addressed in different ways: In transition research, visions are seen as an important determinant of success. They are defined as 'qualitative societal goals and ambitions that evolve through new insights, knowledge and experiences derived from short-term experiments' [30].

Yet, this line of theorizing in sociology of futures, tends to see constructions of the future (visions, scenarios, predictions and narratives) as *explanans* (that which explains transformation) [81] and seeks to capture how they trigger or drive transitions. The vision or imagination is thought somehow as being apart from and external to the project to be realized instead of being, as the STI framework suggests, integral to the very conceptualization of

particular projects as worthwhile and deserving to be realized. Discursive and co-productionist scholarship in the STI framework, by contrast, offers a different take on the performativity of visions of the future, looking at the construction of the future as an *explanandum* (that which should be explained). Imaginaries of T2S, in our terms, are not just strategic and action-forcing representations of the world as it *is*, but also concurrently representations of how collectives want that world to *be*. They are not offered from outside to influence behavior but are generated from within a society, reflecting collective histories and commitments [12]. Making imaginaries is a performative practice situated within particular cultural settings and actively involving the constitution of objects, identities, discourses and institutions that express a society's, or social group's, distinctive orientations toward the future. STIs in this respect are constitutive: they crystallize the policy focus — the scope and areas of political intervention — that a society deems desirable and attainable [82].

Taking the multidimensional nature of co-production seriously, the emergence and enactment of alternative visions are objects of research in their own right. Interpretive approaches explore how visions of alternative futures come about and gain traction. Such a dynamic approach may help to reconstruct the subtle processes through which assumed *lock-ins, path dependencies* and *incumbency* are challenged and apparently immovable structures are reimagined as open to change. From this perspective, it is possible to consider the negotiation of agency within broader *horizons of possibility* offered by sociotechnical change; that is, to see how people's agency is imagined as opened up or constrained by global and local imaginaries [37,83].

STIs are not merely constitutive and futuristic; they can also serve justificatory purposes as instruments of legitimation. In this function, these well-articulated visions of the future 'are deeply political as they either give permanence to the existing state of affairs or help further new lines of action'. Similar to earlier research on discourses and narratives, it is important to ask how materialized visions of the future enable and enact political imaginations by challenging or justifying policy choices and delaying or furthering the search for alternative transformative strategies [84]. If imaginaries offer legitimation for *business as usual* pathways and *incremental change*, they reinforce the path dependency, lock-ins [57] and durability of sociotechnical infrastructures [75]. By making visible the precursors of such constructs, co-productionist T2S research promotes a more 'explicit accountability for the kinds of futures' that specific actors would like to project onto collective futures [52, p. 83].

Constitutional moments
In order to understand how radical departures from the present can be introduced into imaginations of sustainable futures, it is useful to explore moments of fundamental change in dominant framings and processes of policymaking by identifying politically salient shifts in the discursive and instrumental landscape of policy [81,82]. Crucially, such inflections should not only be seen as punctuation points in a particular ongoing narrative of change, but typically also represent moments of shifting accommodation between groups contending over competing narratives. By staying alert to this breadth of possible reorderings, researchers can pay attention to discontinuities and breaks with particular pasts in order to chart distinct futures. These *moments*, which mark a departure from societal path dependencies and inertia, have been defined as 'critical junctures' [85,86], and they typically involve the foregrounding of new normative commitments.

Jasanoff has defined the brief periods in which basic rules of political practice are rewritten — including those governing policy-relevant knowledge and expertise — as 'constitutional moments' that fundamentally transform the relations between citizens and the state [87–89]. These reorderings refer not only to formal constitutional principles by which state institutions legitimate their relationships with citizens but also to tacit reconstructions of state–society or public–private relations. When constitutional moments are compared across countries the STI approach makes visible the emergence of radically transformative visions which had not previously appeared on the radar and allows us to explore how they become thinkable and tangible. These moments offer windows of opportunity in which risks (e.g. of nuclear power, GMOs, or urban surveillance systems) are reframed with notable consequences for politics and governance. In the case of nuclear power, for instance, an alertness to the multidimensionality of STIs allows one to see how diverse concurrent forces came to be aligned behind moves towards the *Energiewende* or the *Nuclear Renaissance* (each with its associated interests, processes and visions of possible transformation). Despite the ostensible set-piece, structural contrasts between, for example, the UK and Germany, each country displays extended periods within which the dynamics of unfolding change can be seen clearly to resolve into radically contrasting forms, conforming to imaginaries shaped by memory, experience, and institutional practices [22]. In such moments of salient change, the power of expertise and its use by authoritative institutions is revisited and renegotiated in society, thus allowing for new ways of organizing democracy and rethinking social order to emerge.

The STI concept helps us to identify the (dis)continuities in the ways in which imaginaries reconstitute underlying constitutional relationships in the triad of state–society–environment [90]. Through this lens, T2S research can highlight the implications of particular visions of transformative sociotechnical change in political terms: for

example, how citizenship gets imagined and enacted; who gets to participate and who is entitled to speak for sustainable futures, as well as who does not belong and hence lacks such voice. Much recent STS research has pointed to 'machineries for making publics' [91,92], highlighting how the very settings in which any form of participation can happen, which are shaped in turn by wider understandings of what democracy means, configure the roles and identities citizens can take on, and thus the very meaning of citizenship. More T2S research is needed on the ways in which publics can be invited to participate in building visions of T2S that take a wider range of values into account, how such participation can be facilitated by extant political mechanisms (e.g. provisions for dissent and local citizen autonomy), and how citizenship is reconstitutionalized through transformations in technologies and national self-imagination [42].

Stabilization and public enactment

Constitutional moments thus offer an opportunity to analyze how actors and communities assemble alternative plans of action as they draw on competing sociotechnical imaginaries to frame sustainable futures and mobilize support from new coalitions of motivations, meanings and ethical, social and political concerns [25,93]. When effectively enacted, STIs can enable or catalyse extended socio-political networks. Case studies of fossil futures illuminate the possibility of bringing together such coalitions, including the 'incumbent' fossil related business and industry, around a new imaginary breaking out of lock-ins in fossil futures and in creating new shared perspectives on a future based on renewables [81].

To make novel visions of desirable futures actionable in the public sphere, as opposed to fictional expectations or incipient vanguard visions, they must become 'collectively held, institutionally stabilized, and publicly performed' [1••,52, p. 83]:

They need to be *collectively held* and can be institutionalized, for instance, by the allocation of resources, the development of research priorities or in particular procedural configurations [15].

In order to become *stabilized*, imaginaries also have to be *publicly performed* [1••]. Work on nuclear energy, for example, has shown how visions of desirable futures are created through memory practices and continuous processes of articulation and rehearsal, as well as embedding in material systems that are shown to work. Public performance is related to the persuasive power of the people, institutions and objects that speak for science or policy. They also have to align with deeply embedded styles of evaluating knowledge claims in the public sphere [94], or civic epistemologies.

Studies of energy transition demonstrate that it is important not only to focus on dominant, hegemonic, and central imaginaries that have shaped and continue to shape our ideas of attainable futures but to query their relations to alternative, collectively held visions that were not taken up by public or private decision makers. STIs help explain why — out of the universe of possibilities — some envisionings of scientific and social order tend to win support over others — in other words, why some orderings are co-produced at the expense of others, and in reverse how other orderings could gain ground through new forms of politics. In order to understand the politics of T2S, co-productionist and interpretive approaches explore how, in which sites and by which actors particular imaginaries of T2S come about, and are rehearsed as well as *why* they become performative, and where and why controversies have emerged [95].

Conclusion: rediscovering the politics of T2S

What lessons can be learned from setting out the STI approach to better understand the multidimensionality, temporality and political nature of T2S?

First, empirical research on STIs enables us to reconstruct where alternative visions and enactments concerning desirable or resisted futures (such the UK *nuclear renaissance*, German *Energiewende* or India's opposition to GMO food crops) come from, how they take shape and solidify [81].

Second, constitutional moments are promising units of analysis in transition [96,97] and T2S studies in order to analyze the conditions under which dominant imaginaries are challenged and opened up to change. It can be used to deepen the analysis of particular, often quite short time-spans during which diverse counter-hegemonic narratives emerge and how they fit together in ways that either dislodge or are marginalized by extant arrangements. It offers a window of opportunity for studying the dynamic and controversial nature of T2S. Transformations may not simply proceed as steady continuous processes, in which the only temporal questions are about the speed, magnitude or acceleration of change in some particular direction between earlier and later steady states. Instead, transformations may unfold in highly discontinuous ways, implicating multiple dimensions for change and even iterating between concurrent imaginations and sociotechnical formations.

The German Energiewende, for instance, was triggered by external shocks such as the nuclear accidents at Chernobyl and Fukushima, but was embedded into and enabled by a national culture of risk regulation and mobilized by an energetic environmental movement [90]. Studying STIs in the making also indicates that there is neither a single causal factor for explaining radical change nor a single leverage point for enabling transformative

change. Such cases call for addressing the full dimensionality of transformation in more detail.

Third, taking the dimensionality of T2S seriously, a challenge for the future is to unravel the mutually reinforcing entanglements between alternative visions of sustainable futures (such as energy futures with or without nuclear power) and transformative strategies (such as democratic and decentralized forms of political representation) in order to understand how they come to close down or open up our imaginations of societal transformation. Set-piece categorizations of prior and subsequent states — or of linear processes of transformation between them — can be questioned in ways that open up the politics of such processes.

Fourth, research on STIs also indicates that shifts in imagining sustainable futures do not automatically translate into transformations of political practices or into effective policies. STIs help us to understand how and why visions of a sustainable future can legitimate, rather than challenge, cognitive *path-dependencies* and material or discursive *lock-in*s, thus reinforcing entrenched power structures and resource-intensive lifestyles rather than rendering them open to change [57,75,98]. The STI lens allows us to display aspects of transformation that remain obscured and explore why particular technical solutions (such as carbon removal technologies) have emerged as the right options to address global environmental problems. By more explicitly and accountably addressing the ways in which understandings of transformation are co-produced with the structures and practices that seek to drive and resist them, the STI approach puts a spotlight on how it is not simply transformations that are political, but also the shaping of knowledges about them. It reveals, for instance, the paradox that narratives of change can contribute to delaying radical societal transformations because they focus on technological systems without querying the governance structures underlying them []. The stabilization of alternative visions and their enactment also call for more attention. A major future challenge is to understand better how alternative visions and transformative practices resonate with the societal values and political structures and technical infrastructures in which they are embedded [90].

Fifth, case studies of energy futures indicate that questions of 'who gets to imagine the future' [99], 'whose visions and actions count?' and 'who will bear the risks and benefits' are not properly considered in the emerging literature on transition, nor are considerations of which actors are included or excluded from decisions about future sustainability transformations [60••]. To address this gap, STS scholars pay attention to emergence of counter-hegemonic imaginaries that are marginal, distributed, and decentered and less readily codified, documented, and publicized [60••]. Asking who gets to imagine

transformative change, especially at constitutional moments, shows the connections between visions and values attached to sustainable futures and the politics of knowledge brought to support them.

In practical terms, research strategies seeking to enable transformative change need to attend better to diversities of visions, actors and commitments that are present when one looks beyond dominant reductive and linear framings. Doing this reduces the risk that visions of transformative change close down, rather than expand, the range of pathways, and the diversity of actors and their visions contributing to them.

Recognizing the domain of sociotechnical imaginaries as a field of political action, and investigating the forms of participation and representation that shape those imaginaries, are essential steps toward reclaiming for this century's citizens a democratic politics of the future [100]. The coronavirus crisis reveals much about the infrastructures of modernity that are also at play in supporting environmentally unsustainable futures. The largest challenge of currently ongoing T2S research is to discern within the chaos of this *global* constitutional moment the seedlings of promising futures that our research can make visible for willing and committed actors.

Conflict of interest statement
Nothing declared.

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References and recommended reading
Papers of particular interest, published within the period of review, have been highlighted as:

- •• of outstanding interest

1. Jasanoff S, Kim SH (Eds): *Dreamscapes of Modernity:*
•• *Sociotechnical Imaginaries and the Fabrication of Power*. University of Chicago Press; 2015 http://dx.doi.org/10.7208/ chicago/9780226276663.001.0001.
The edited volume marks a major theoretical advance for a concept that has been rapidly taken up across the social sciences. Dreamscapes of Modernity offers the first book-length treatment of sociotechnical imaginaries, a concept originated by Sheila Jasanoff and developed in close collaboration with Sang-Hyun Kim to describe how visions of scientific and technological progress carry with them implicit ideas about public purposes, collective futures, and the common good. The book presents a mix of case studies—including nuclear power in Austria, Chinese rice biotechnology, Korean stem cell research, the Indonesian Internet, US bioethics, global health, and more.

2. Scoones I, Stirling A (Eds): *The Politics of Uncertainty: Challenges*
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This book introduces new ways of reimagining how society can engage with uncertainty — ways that prioritize alternative visions and open the possibility of participation and experimentation along the way. It shows

how sustainability, transformation and development are not just technical issues, but depend deeply on political values and choices. Reflections on why uncertainty is so important to politics today and what opportunities can emerge from what cannot be known are illustrated by multiple case studies from across the world, including finance and banking, insurance, technology regulation and critical infrastructures, as well as climate change, infectious disease responses, natural disasters, migration, crime and security and spirituality and religion.

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