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The Politics of Accelerating Low-Carbon Transitions: Towards a New Research Agenda

Abstract:

Meeting the climate change targets in the Paris Agreement implies a substantial and rapid acceleration of low-carbon transitions. Combining insights from political science, policy analysis and socio-technical transition studies, this paper addresses the politics of deliberate acceleration by taking stock of emerging examples, mobilizing relevant theoretical approaches, and articulating a new research agenda. Going beyond routine appeals for more 'political will', it organises ideas and examples under three themes: 1) the role of *coalitions* in supporting and hindering acceleration; 2) the role of *feedbacks*, through which policies may shape actor preferences which, in turn, create stronger policies; and 3) the role of broader *contexts* (political economies, institutions, cultural norms, and technical systems) in creating more (or less) favourable conditions for deliberate acceleration. We discuss the importance of each theme, briefly review previous research and articulate new research questions. Our concluding section discusses the current and potential future relationship between transitions theory and political science.

Keywords:

Socio-technical transitions, political science, temporality, accelerated transitions, coalitions, policy feedback, context dependency.

Technological systems with the potential to reduce global carbon emissions have been expanding rapidly, driven partly by impressive developments in areas such as solar panels, wind energy, and electric cars [1–3]. This progress, however, remains too slow to keep global climate change within the two degree limit set by the Paris agreement, let alone its 1.5 degree "aspirational" target. This situation has created an urgent debate over whether and how the necessary changes can happen quickly enough [4], to which many scholars offer pessimistic answers. Smil [5], makes a particularly compelling historical argument that transitions in energy systems are "long and arduous."

If they are to succeed at mitigating climate change, therefore, the pace of transitions to low-carbon energy systems must somehow differ from historical precedent. This will require an *acceleration* of the pace of change. There is some reason for hoping that such an acceleration could be plausible. Past energy transitions have been triggered by a largely emergent combination of policy efforts, economic shifts, technological developments, and other factors. While currently ongoing low-carbon transitions also benefit from emergent technical, economic and cultural developments, however, they are also being actively pushed by policymakers on an international level, in a way unlike any other energy transition on historical record [6,7]. Sovacool's [8] list of 10 rapid energy transitions, some of which went from a 1 percent to 25 percent market share in just a few years shows that this kind of acceleration can achieve impressive impacts. This has provoked significant debate, on whether Sovacool's relatively small-scale examples can have a bearing on the global energy transitions necessary to mitigate climate change [9–12].

A cursory survey of climate mitigation policies, however, suggests that the kinds of aggressive efforts necessary to dramatically accelerate transitions to low-carbon energy are not yet being seen in practice. Governments around the world have not only refrained from making serious efforts to deliberately accelerate low-carbon transitions; they continue to actively support fossil fuel industries, for example through fossil fuel subsidies and support for road and aviation infrastructure [13,14]. The literature on socio-technical transitions provides a simple explanation for this, namely that entrenched incumbent systems enjoy political power and therefore policy influence [15,16].

It follows that an important question in the debate over the pace of future transitions—be they climate or sustainability focused—concerns whether, how, and to what extent governments can create and/or do exploit the political conditions to escape the *political* lock-in of the status quo, and deliberately accelerate the pace of change. The politics of low-carbon transitions have already been widely studied [12,13,15,17,18]. The crucial issue of the *politics surrounding their deliberate acceleration*, however, remains under-examined. This important topic was the subject of a workshop held at the University of Manchester in July 2017, at which scholars from the two most relevant communities (political science and innovation/transition studies) discussed the politics associated with the deliberate acceleration of socio-technical transitions. During this workshop, and in the course of subsequent discussions, three themes emerged that are relevant for the further development of scholarship in the deliberate, political acceleration of transitions.

> **1) The role of *coalitions* in creating the political conditions for transitions.** Incumbent systems are protected by powerful coalitions that can significantly oppose and obstruct low-carbon transitions. But there may also be coalitions in support of them, which could be strengthened by state action.

2) *Feedbacks* and stability. Policies create feedback effects, which can be either positive, locking in those policies, or negative, choking them off. Policymakers might be able to build positive feedback into the design of policies.

3) *Context dependence*. Complex dependencies on local factors such as governance structures, culture, or economic systems can lead to significant variety in the kinds of strategies that are successful in different political jurisdictions.

These themes overlap with the 2017 Sustainability Transitions Research Network research agenda [19], which identified power, agency, and politics as a key direction for further research. In this discussion, the research agenda identifies "the *agency* of the various actors involved in transition processes" [19], and the *politics* of transitions, noting that "scholars in the transition field have started to move beyond simply analysing the content of public policies to think more systematically about the politics of policy processes and how they shape policy outputs" [19]. The role of coalitions is particularly important for the topic of agency and expands on it, broadening from a discussion of the agency of different actors, to a discussion of how actors can combine and strengthen their political agency; a key concern for those trying to build political support for marginal niche-innovations. The theme of feedbacks and stability, similarly, further develops the topic of politics as described in the research agenda, showing how the outcomes of political processes can influence future political processes, building political momentum for transitions. While our third theme of context dependence does not fit so tidily into the research agenda, it does speak to the critical importance of *structure* in influencing political outcomes.

These three themes thus address three core issues in the political acceleration of socio-technical transitions: a*gency* (of political actors), *process* (the iteration of policies and their results and feedback effects), and *structure* (the broader political, economic, cultural, and geographic context of the transition). Thus, while they were developed informally through workshop discussions between experts, they are useful as rough organising principles for different kinds of unanswered questions which recur frequently in debates over the deliberate acceleration of low-carbon transitions. These themes are neither comprehensive nor mutually exclusive (and in fact, the interconnections and cross-pollinations between them are explicitly explored in the conclusion of this article). Instead, they provide a starting point for further debate and research on the politics of transitions. The remainder of this article suggests directions for these debates and research efforts. Each of the following three sections examines the work that has already been done on one of the themes, and suggests new topics for research. The concluding section considers the implications of these discussions for low-carbon transitions more generally.

Theme 1: The Role of Coalitions

Policies aimed at the deliberate acceleration of low-carbon transitions do not always have an obvious constituency. Reforms in areas such as taxation, or social services have clear benefits for groups such as businesses, consumers, or pensioners (and often equally clear detrimental impacts for other groups, such as wealthy taxpayers). The beneficial effects of low-carbon transitions, on the other hand, are displaced in space and time from those who pay for them. Nevertheless, it is important to find ways to create supportive coalitions for the deliberate acceleration of low-carbon transitions despite this difficulty. The importance of these coalitions is easily demonstrated. Firstly, no single actor has the resources (expertise, money, legitimacy, organisation and leadership) to bring these transitions about.

Secondly, within government, business, and civil society there are actors who seek to advance transitions and others who seek to impede them. Progress in accelerating change therefore depends on the formation of supportive coalitions, which we define loosely as alignments of disparate groups across government, business, and civil society, united by common interests or ideas.

Empirical studies on the politics of low-carbon transitions further support this argument, and also reveal some important features of successful coalitions [20–23]. Newell and Paterson [22] argue that they "will have to be supported (financially and politically) by powerful fractions of capital with a stake in the success of such a project." In their analysis of China and India, Harrison and Kostka [23] find that "state strategies…have focused on the need to bring different parties with otherwise divergent interests on board." Schmitz' [24] analysis of successful climate-relevant policies in Brazil, China, India, and South Africa finds that most actors who support these policies have priorities other than climate change mitigation, which might include energy security, building competitive green industries, creating jobs or ensuring future public revenue, with climate change mitigation seen merely as a "co-benefit". This implies that low-carbon transitions can draw on support from a wide constituency beyond just those with green convictions, and that the deliberate acceleration of low-carbon transitions is most politically effective when climate benefits are combined with more politically resonant issues, such as personal health, jobs, or security. This comes out clearly in examples of successful energy transitions. In the Danish transition to district heating, for example, the state cultivated a successful coalition of users, municipalities, and local cooperatives based on shared principles of energy security, low-cost heating, and cooperatism [25,26].

Another important, and largely unaddressed issue, is coalition structure. Different types of alliances, based for example on advocacy [27], or discourse [28], can emerge in different circumstances. Coalitions can also range in their level of coordination from the *strategic alliances* to mere *alignments of interest*; they can be either *consciously pursued* or *incidental* [29]; and they can range in longevity from *transitional* to *enduring*, with incidental alliances more likely to be short term. While information on the longevity of alliances is limited, short term alliances, focused on specific initiatives, could play a bigger role than assumed, and ad-hoc coalitions could be an important vehicle for accelerating low-carbon transitions.

It is also important to address and further document the political coalitions that slow down or block low-carbon transitions; a phenomenon implicit in many studies on path dependency and policy lock-in [16]. These coalitions can oppose deliberate acceleration using strategies including lobbying, exaggerating uncertainty, questioning scientific evidence, and watering down regulatory efforts. They often benefit from asymmetries in power, such as unequal access to resources or representation [12,14,30,31]. Breaking this resistance is critical for the deliberate acceleration of low-carbon transitions. Pierson [32] argues that major policy changes require a 'breakdown in the factors reinforcing the status quo'. Similarly, Geels [14], Turnheim and Geels [33,34] argue that the destabilisation of existing regimes requires more attention in studies of transitions. Many historical transitions have been made possible by the absence, weakness, or deliberate disarming of the incumbent coalition. The very rapid Dutch transition to natural gas power, for example, benefited from an ailing coal regime, but transition policies also further disarmed this possible source of resistance by giving coal companies key positions in the natural gas regime, and by retraining coal miners [35][37]. Similarly, the British transition from railways to roads as the dominant transport surface transport system was facilitated by severe commercial, infrastructural, and political problems within the incumbent rail regime at precisely the moment when

road transport became viable competition (Aldcroft, 1975); while the Danish transition to district heating after the 1973 oil crisis was facilitated by the lack of any strong domestic oil industry to oppose the change (Eikeland and Inderbert, 2016).

The 'stranded assets' debate, emphasising the risk to fossil fuel industries as climate mitigation policies force them to keep most of their reserves in the ground, provides a clear indication that the policy lock-in described above can crumble [38]. Fossil fuel companies have been encouraged to disclose their climate-change related risks and investors have been encouraged to divest and shift their assets to renewable energy sectors. This debate raises the question of how the coalition supporting change can recruit from the coalition that resists change, and also shows that coalitions are often created in response to, and enabled by, existing policies. This issue is further explored in the discussion on policy feedback, below.

The key points coming out of our discussion of Theme 1 are that coalitions of government, business and civic actors matter for accelerating transitions [36], and that in practice, they are often opportunistic alignments of actors motivated by concerns other than mitigating climate change. These coalitions, furthermore, must fight an uphill battle to defeat counter-coalitions. This perspective, which should inform further research on who drives coalitions, suggests several specific research questions. Future research should investigate the composition of successful and unsuccessful alliances, including by looking at the relative effectiveness of alliances of different structure and longevity. Researchers should also consider the temporal development of coalitions and the political shifts they aim to influence, looking at what changes in coalitions can result in political tipping points; the causes and effects of coalitions changing over time; and the ways in which low-carbon policies affect coalitions (see Theme 2). Finally, more attention should be paid to the origins, power base, and effective disarmament of the incumbent coalitions blocking change. This should be aimed at finding ways to deliberately foster the creation of durable, broad, and effective coalitions in favour of low-carbon transitions.

Theme 2: Feedbacks and Stability

The makeup of coalitions supporting and opposing policies aimed at low-carbon transitions is influenced by the nature and outcomes of previous policies. This insight, summed up in the phrase 'policy makes new politics,' forms the core of a growing literature on policy feedbacks, the modern version of which was pioneered by Theda Skocpol [37] and Paul Pierson [32,38,39]. It shows that the effects of policies can be very broad ranging and long lasting. These include the creation of new organisations, institutions, vested interests, and preferences among interest groups and mass publics. These can in turn create new sources of political support for the initial policy, thereby making it harder to dismantle [40]. Policies can also, however, generate negative feedback effects [41–44]. For example, a policy may cause new groups or coalitions to form that oppose it, resulting in its eventual dilution or abandonment. This feedback dynamic can be exacerbated (or ameliorated) by exogenous factors, such as technical or financial developments.

These effects are important for the deliberate acceleration of low-carbon transitions, because these typically unfold over long time frames. To be effective, deliberate acceleration policies must thus not only be substantively effective (i.e. reduce emissions), but also encourage positive feedbacks and avoid or mitigate negative ones [45]. It is also important to note that this momentum may come from coalitions that were not present when the policy was originally designed and adopted [42].

Thus far, however, the literature on the politics of low-carbon transitions has tended to use the concept of policy feedback rather implicitly [46–56], though there are some exceptions to this. Jordan and Matt's [44][46] study of the EU voluntary agreement on CO_2 emissions from new cars, for example, shows that attempts by the European Commission to create positive feedback effects were blocked by the automotive industry. However, one significant feedback effect did occur in the form of new flows of information that allowed the coalition pressing for decarbonisation to demonstrate the failure of voluntary agreements (which were the car industry's preferred alternative to regulation). Lockwood [45] compares feedback mechanisms and effects in renewable energy policy in the UK and Germany, showing that while electricity costs and landscape impacts have created negative feedbacks in both countries, positive feedback effects, supportive constituencies, and political stability did emerge from more distributed ownership patterns and more supportive industrial policy in Germany. This suggests that the details of policy design and institutional context play a key role in shaping policy feedback effects. Eikeland and Inderberg [57] provide a similar analysis of positive feedback effects in Danish renewables policy.

The concept of policy feedback concept offers huge untapped potential to look beyond the often narrow focus of innovation policy analysis [58], to consider the political aspects of low-carbon transition policies including support for renewables deployment, grid integration, electric vehicle and low carbon heat policies. There is, however, still work to be done to link the concept fully to the needs of low-carbon transitions.

This work is needed because socio-technical transitions are a uniquely complex area in which to study policy feedbacks, for two kinds of reason. One is that the mechanism connecting policy outcomes to political pressures includes not just interest groups, but a complex, ever-changing, and mutually-dependent assemblage of large technical systems, market dynamics, user preferences, and radical niche-innovations [33,59]. Thus Schmidt and Sewerin [60] argue persuasively that technological change can also have political feedback effects. In many cases such feedback will be positive because it arises from policy-induced technology cost reductions, although such reductions have themselves sometimes triggered negative feedback effects arising from investment 'booms' and rapidly increasing policy costs, for example in solar PV support programmes [61]. Technology effects can also work through routes other than cost, for example in the case of the development of larger turbines, which has provoked opposition to repowering of onshore wind in Denmark [47].

A second reason lies in differences between the nature of policy in the deliberate acceleration of low-carbon transitions and policy in the area that much of the existing literature on policy feedback has focused on to date, i.e. social policy. For instance, transitions involve sequential policy changes needed to maintain and accelerate energy system transition [62]. This stands in sharp contrast to many social policies—for example those involved with the creation of new pension or health system arrangements which typically require the protection of a one-off policy change [63].

Another important difference is that the existing literature is generally concerned with distributing benefits, which tend to nurture specific supportive constituencies (such as welfare recipients), for whom the benefits of the policy in question are obvious. Feedback effects arising from decarbonisation policies may be rather different [63]. For example, regulations requiring up-front investments in new technologies (such as pollution control equipment) are likely to generate more forceful positive feedbacks than regulations requiring the publication of information on emissions [64]. This raises

questions about the *political* implications of employing market mechanisms, such as carbon taxes, as opposed to policy interventions such as subsidies and targeted regulations.

This leads to perhaps the biggest challenge, which is that the literature on policy feedbacks has mostly analysed the unintended effects (mostly triggered by positive feedbacks) of policies, rather than the extent to which policy makers *intentionally* generate feedback effects. This is a gap that studies on policy feedbacks in deliberately-accelerated transitions should try to bridge, as deliberate cultivation of policy feedbacks could be crucial in maintaining the political consensus necessary for radical policy changes to accelerate low-carbon transitions [44]. There are some textbook cases of deliberately encouraged feedbacks in energy policy. For example, the privatisation of gas in the UK by a Conservative government under Margaret Thatcher was aimed at creating a nation of Conservative-voting shareholders [65]. Many of these, however, do not specifically address low-carbon transitions. More research is needed on how far and in what circumstances politicians can intentionally nurture positive feedbacks in support of decarbonisation [63,66]. There are also more specific conceptual and methodological issues to be addressed, such as differentiating between feedback *effects* and *mechanisms*, as well as the interaction between endogenous policy feedbacks and exogenous factors, such as socio-technical landscape events [67].

The theme of feedback and stability is strongly linked to the two other themes discussed in this paper. Transitions (and policies) are often started by coalitions, which may well evolve over time along with the policies they initially supported [42]. Contextual factors, including economic structures, national technological infrastructures, and political institutions will also be an important determinant of policy feedback effects, because context shapes the immediate political consequences of policies [39,45]. This link to context makes policy feedback a particularly apposite framework for comparative research, across contexts or across types of policy.

While the policy feedback literature represents a mature area of policy theory [68], the lack of applications to non-social policy fields means that carefully designed case studies are needed to link it better to the deliberate acceleration of low-carbon transitions. This requires conceptual and methodological work, including the careful definition and identification of the mechanisms and effects of policy acceleration or reversal (see Pierson [69] as a model). A challenge here is that there are few, if any, completed low carbon transitions that can serve as case studies. Another challenge is how to move from single instruments to policy mixes and broader policy programmes [63]. Ultimately, effective policies for accelerating low-carbon transitions must create positive feedbacks and minimise negative ones. This requires a more forward-looking analysis of when, how and why policy makers intentionally design policies that create strong feedbacks [38,63]. This research should be done specifically with low-carbon transitions in mind, and should include an explicit account of how policy feedbacks interact with wider socio-technical dynamics.

Theme 3: Context Dependence

The nature and speed of low-carbon transitions varies enormously between different national, regional, and local contexts. Some jurisdictions, likely due in part to their material, socio-political, and economic context, have had more success in the deliberate acceleration of low-carbon transitions than others [70]. This is critical because to be successful at limiting climate change, the deliberate acceleration of low-carbon transitions must happen successfully in a wide variety of contexts. The influence of context

on transitions is likely to be shaped by factors discussed in both themes considered above. The effects of diverse political economics will partly shape coalitions both supporting and opposing change, institutional context and associated ideas can influence the immediate impacts of policies, and the extent to which these impacts create feedbacks. Temporal context is also important. Depending on the configuration of political and economic forces at any one time, 'windows of opportunity' might open up around which discourse coalitions [28,71], policy entrepreneurs and new coalitions of interest can mobilise to accelerate change [72].

Key contextual dimensions which may affect the scope for the deliberate acceleration of low-carbon transitions include technological capabilities; natural resource endowments, industrial specialisation, and cultural repertoires, such as Swedish collectivism, Dutch consensus-based society, and the emphasis on individual freedoms that predominates in the United Kingdom and the United States. Transitions are crucially shaped by very different contexts. Incumbent regimes, for example, can enable or frustrate the pace of change, depending on their relationship to landscape pressures [73,74]. These contextual factors have led to important differences in how different political jurisdictions have succeeded at, failed at, or refrained from attempting low-carbon transitions [75].

One obvious contextual factor affecting deliberate acceleration is cultural or political norms. For example, the level of resistance to nuclear energy in Germany compared with France, or to fracking in the United Kingdom compared with the United States show that policy success in supporting certain technologies can depend a great deal on their cultural legitimacy, which depends on local cultural and discursive factors. Roberts [76] shows that broad cultural discourses, (an anti-trust mentality in his case study on the American railways), can destabilise powerful incumbent socio-technical regimes. Kuzemko et al [18] show the importance of democratic structures, norms and values in governing energy system change. Differences between institutional contexts in countries such as the UK and Germany are highlighted by Lockwood [45] as a major factor explaining levels of support for deliberate acceleration policies in each country (also see Ehnert et al [77]).

Another important element of the context is political economy [78–80]. Different 'political coalitions' spanning government institutions and industry [15,48], as well as the nature of the state [81], can play a key role here. Political economy accounts of transitions also emphasise the power of incumbents to slow the pace of energy transitions [14], as with the Minerals-Energy-Complex in South Africa [76]. Other work looks at the role of external actors, such as donors and businesses, in shaping the nature and pace of energy transitions [79], and the historical circumstances in which more rapid and disruptive change has been possible [7,82,83]. This includes historical examples where transformative change has been facilitated by new normative frames imposed by circumstances such as wartime or technological "revolutions" [67,84–86]. Haley's [87,88] work on the political economy of Canadian energy shows another way that political economies can make low-carbon transitions much more difficult. Canada, being a peripheral, natural resource-supplying country, is locked into a "staples trap," in which sunk investments and political commitments heavily favour incumbent extractive industries, including those associated with oil and gas.

Relatedly, a number of scholars [18,89] have explored potential links between the speed and direction of low carbon transitions and institutional systems endemic to different "varieties of capitalism" [90]. Whether market economies are organised along liberal lines (such as in the United States and United Kingdom) or coordinated lines (such as in Germany and the Netherlands) may help to determine the

scope for an 'entrepreneurial state' [91] to deliberately steer investment in technology and infrastructure (see e.g. Mikler and Harrison [92]). Evidence is mixed on whether coordinated market economies are better at accelerating low-carbon transitions [93–96]. Institutions and policy paradigms that are effective at accelerating low-carbon transitions are unlikely to align completely with those identified in the varieties of capitalism literature, which emphasises interrelationships between labour markets, welfare, electoral systems and types of innovation. There is also a need to relate national situations to global contexts in order to avoid the 'territorial trap' of viewing these developments in isolation where comparative advantages in research and development, manufacturing and installation combine in different ways across settings [97]. Low-carbon transitions involve different issues and institutions, including those relating to the physical structure of technological systems. Offshore wind in the UK provides an interesting example of a liberal market political economy which has nevertheless allowed a high degree of coordination and industrial policy activism [98]. State intervention strategies also differ in terms of how states act or do not act, according to underlying 'policy paradigms', and 'qualities of democracy' [98].

The critical importance of contextual factors has been made clear in the ongoing debate over the temporality of future energy transitions, as discussed in the introduction to this article. In this context, it has major implications not just for ontology or practical implications, but also for methodology, such as the question of how we measure rapidity. As discussed in the introduction to this article, there is already a live debate among transition scholars about the speed at which past transitions have occurred. Hence, attempts to start with cases of seemingly accelerated transitions and then trace back to contextual factors should proceed with caution. Explicit discussion of timescales needs to acknowledge that different dimensions of transitions proceed at different speeds; for example, legislation can change much more quickly than culture [99].

Nevertheless, trying to establish, using contemporary and historical examples, which combinations of contextual factors allow for accelerated transitions, might offer fertile ground for future research, providing they counter the assumption that the right policy mix can be universally applied across diverse systems, economies and political institutions. Transitions pathways approaches [100–104] suggest one way to explore the possible courses of actions occurring in different contexts. This is an important challenge, in light of the fact that much of the existing research on politics and policies for energy transitions is based on northern European case studies. This empirical scope should be expanded, particularly to include non-Western and developing countries. While there is already promising research on low-carbon transitions in these contexts [105,106], research on the politics of deliberate acceleration in particular should focus on these contexts, in order to avert the European bias.

One politically awkward question is about whether top-down interventions are desirable. Many European countries in the post-war era, as well as present-day China, have relied heavily on major planning projects. This approach, however, while potentially an effective response to climate change, comes with the risk of 'post-politics': invoking urgency to shut down discussion of alternatives and ultimately supporting entrenched interests [103,107,108]. This speaks to the need to take care that the promotion of directed models of change also allows for the articulation and promotion of attractive and radical visions of the future. As Turnheim and Geels put it [33]: "For low-carbon transitions, this means that alarming climate scenarios may be less effective in generating public support than positive visions of low-carbon futures (which should include other features than low carbon emissions)." This links up with a point in the first theme: Publics are typically more enthusiastic about so-called "co-benefits" of

climate policies, rather than carbon mitigation. Visions of low-carbon futures should thus be centered around material benefits for the public, rather than merely on the reduction of carbon emissions.

The key questions in this theme can be grouped into two categories. The first concerns the range of contextual factors that can influence efforts to deliberately accelerate transitions. This should involve detailed, systematic, and comparative research into the interdependent impacts of different political economies, institutions, cultural norms, technical systems, and geographies. Secondly, work in this theme should address the methodological questions concerning the use of case studies from different contexts to inform policy choices and political strategies. This has implications for arguments on both sides of the temporality of transitions debate. On the one hand, it could invalidate the use of some case studies, such as those used by Sovacool [7] purporting to show the potential for accelerated transitions. On the more optimistic side, however, it could counter arguments such as Smil's [5] to show that transitions, given the current urgent context of climate change, will not necessarily be prolonged affairs.

Conclusion

Our list of three themes is not exhaustive, but it has turned up some very important points. Each theme, first of all, suggests not just obstacles but also opportunities for deliberately accelerating low-carbon transitions. Theme 1 shows the major obstacle posed by counter-coalitions, but also fruitful and perhaps underexploited opportunities to build new coalitions. Theme 2 reveals the potential obstacle to change posed by negative policy feedbacks, but also offers the tantalising possibility of designing positive policy feedbacks that further accelerate decarbonisation. Theme 3 uncovers a major theoretical and methodological obstacle inherent in trying to apply insights from one context to another, but also suggests that some contexts can be particularly fruitful for low-carbon transitions.

The three themes are potentially very tightly interconnected. For example, transitions (and policies) are often initiated by coalitions (see Theme 1), but for policy feedback scholars, the adoption of a policy is not the end of the story [42]. Policies and their supportive coalitions are likely to co-evolve over time. At the same time, institutional context, including economic structures, national technological infrastructures, and political systems (Theme 3) will be an important determinant not only of the shape of initial coalitions supporting and opposing transitions, but also of policy feedback effects, because context shapes both the immediate impact of policies, and the political consequences of those impacts. In fact, policy feedback emerges as a very useful middle level concept around which research crosscutting the three themes can be organised.

Table 1 summarises our discussion of these three themes, revealing important cross-cutting issues and tensions in the political acceleration of transitions. Firstly, there is an important question of *beneficiaries*. Because the responsibility for, and benefits from, mitigating climate change are often dispersed across the world and over decades, it is often difficult to identify clear beneficiaries of climate change policies among target groups. This makes it challenging to amass durable coalitions in favour of accelerating transitions, and can make transition policies prone to more negative feedbacks than positive ones.

Table 1: A summary of the three themes.

	Theme 1: Coalitions	Theme 2: Feedbacks and Stability	Theme 3: Context dependence
Key perspectives and takeaways	-Coalitions of actors are critical for transitions. -Actors supporting transitions often have priorities other than mitigating climate change. -Incumbents form coalitions to reinforce the status quo.	-Transition policies must be not only successful, but stable and self-perpetuating, encouraging beneficial positive feedbacks while minimising destabilising negative feedbacks.	-Deliberate acceleration happens differently in different contexts, defined by different political economies, institutions, cultures, incumbent regimes, and other factors.
Debates and unresolved questions	-Which types of coalitions are more effective? -How might changes to coalition makeup lead to political tipping points?	-Who are the key beneficiaries for accelerated low-carbon transitions? -How can transition policies encourage positive feedbacks over the long term? -How can we distinguish the effects and mechanisms of policy feedbacks?	-How can policies accelerate socio-technical transitions in as many different contexts as possible? -To what extent can policy lessons be generalised between different times and locations? -Should we accept top-down transition policies as a potential path to success?
Opportunities	-Finding robust, politically appealing co-benefits to tie deliberate acceleration policies to. -Finding ways to recruit from incumbent coalitions resisting the transition.	-Finding strong policy feedback mechanisms to support and enhance policies accelerating low-carbon transitions.	-Finding contexts that are particularly supportive of rapid low-carbon transitions to help accelerate them more rapidly than would otherwise be possible.
Challenges	-Understanding the role of convening power in different phases of the political process. -Understanding when coalitions can succeed across borders.	-Encouraging positive feedbacks in the face of incumbent industries. -Distilling lessons from advanced transitions for case study purposes.	-Breaking away from eurocentrism by developing case studies in a wide variety of contexts. -Finding rigorous theoretical means of applying policy lessons from one context to another.

The next obstacle is *incumbent resistance*. Deliberately accelerated low-carbon transitions are almost inherently confrontational: If they are successful, they will create clear losers among incumbent regimes. It is not surprising, therefore, that the challenge of defeating the political support of incumbents appears prominently in both the coalitions and policy feedback sections. It is almost impossible to provide a single clear solution, or even a broad set of strategies, to overcome this obstacle, because political actors working on behalf of incumbent regimes are seldom passive –they actively formulate their own strategies, and are as capable of learning from the concepts and case studies discussed here as transition practitioners are. Crucially, they also benefit from larger political and financial resources, as well as an incumbency advantage.

Another issue has to do with the tension between *top-down and bottom-up approaches*. Scholarship on the role of policy in transitions often implicitly favours emergent, bottom-up experimentation and niche development. Some of the most significant challenges and opportunities discussed in this paper, however, such as the need to combat the political power of incumbent actors by bringing in actors from other powerful industries, appear at a system or regime level. Therefore, an alternative governing strategy is to favour more top-down approaches which, rather than opening-up the system to new innovations and experiments, close it down in favour of a single new system which is supported by the state. This, however, might have problematic implications for maintaining coalitions during this close-down process.

Finally, there are issues of *methodological and theoretical compatibility*. Our discussion under the three themes has mobilized insights from a range of theories about politics, policy, and socio-technical transitions, which are sometimes based on different ontological assumptions. Our discussion of coalitions mostly draws on pluralist group theory, in which actors use rational interest-based calculations to decide on coalition participation. But we also referred to advocacy coalitions and discourse coalitions, which have different assumptions about the 'glue' of coalitions (shared beliefs and shared stories respectively). Our policy feedback discussion draws on historical institutionalist theories, which have a more contextual view in which agency (i.e. actors' preferences and interests) is shaped by institutions. This contrasts with interest-based historical institutionalist theories, which see institutions as providing the 'rules of the game' for strategic actors [109]. Our contextual theme draws on political economy and structuralist theories, which focus more on macro-contexts than agency. Because of these different theoretical backgrounds, the insights under the different themes can complement each other. This also creates risks with regard to incompatibilities and inconsistencies, however, which is why we suggest that future research should further elaborate this issue. Future research could also further reflect on compatibilities between policy science theories and socio-technical transitions theories. On the one hand, there are overlaps and similarities. Policy theories' macro-contexts fit well with the idea of a socio-technical landscape, level, while discussions of coalitions and feedbacks in political science fits well with the concepts of niches and regimes: both relate to social networks and co-evolutionary feedbacks [110,111]. On the other hand, the differences in units of analysis (policy change versus socio-technical system change) is likely to have implications for the compatibility between theories from both fields [17,112].[1] Although resolving these foundational issues is beyond the scope of this paper, we suggest that they are not insurmountable and that there is significant potential for cross-pollination between policy science theories and transition studies approaches.

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[1] We want to thank one of the reviewers for alerting us to this issue.

These findings reveal many fruitful but challenging opportunities to adapt political science perspectives to the political need to accelerate low-carbon transitions. In seeking to address the politics of deliberate acceleration, there is much to be gained by bringing scholars of socio-technical transition and political science into a much closer dialogue. To that end, we have advanced several such cross-disciplinary bridges, which can be summarised by a series of questions relevant to each of the three themes:

> 1) How can effective coalitions be developed to support the deliberate acceleration of low-carbon transitions? How can coalitions opposing these policies be disarmed and overcome?

> 2) How do the policies and socio-technical systems create policy feedbacks? How can policymakers exploit them to design deliberate acceleration policies that are not only sufficiently popular to be adopted, but are self-expanding over time?

> 3) To what extent do deliberate acceleration policies depend on their political, cultural, and

If low-carbon transitions are to happen at a pace fast enough to avoid the worst impacts of climate change, they must occur in a qualitatively different manner from past energy transitions, involving careful consideration of all the dynamics identified in this paper. The questions raised here should thus be interesting both from a descriptive and prescriptive point of view. On the one hand, understanding the political prospects for deliberate acceleration policies is critical to considering the speed of future low-carbon transitions. It is also, however, critical to designing policies that are up to the job of achieving rapid and deep decarbonisation.

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