



Bringing the political system (back) into social tipping relevant to sustainability

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ABSTRACT

Recently, social tipping dynamics relevant to sustainability have become the subject of a growing literature. Numerous publications seek to bring the concept of tipping (back) from the natural to the social system and make important contributions to its conceptualization, definition, and constant refinement. Yet, and despite its wide array, the current literature has a blind spot: it does neither adequately integrate, conceptualize, nor measure the role of the political sphere and thus underestimates its importance for social tipping processes. This is the starting point of our contribution, which not only emphasizes the political dimension's relevance to the analysis of social tipping, but also proposes two main ways to integrate it into such analyses: by conceptualizing the political sphere either as a *trigger* of social tipping, or as an *element that can tip itself*. Moreover, to capture the complexity of the political sphere, namely the interaction between networks, actors, and processes, we suggest analysing the political sphere along its three elements: polity, politics, and policy. We illustrate the empirical benefit of these refinements by presenting a comparative case study of the nuclear phase-out in Germany and Switzerland.

1. Introduction

More and more studies point to the many effects of climate change and global warming, be it the danger of a 'Hot House Earth' (Steffen et al., 2018), the hysteresis of ice shelves in Antarctica (Garbe et al., 2020), the degradation of coral reefs (Frierler et al., 2013), or the rising sea levels (Edwards et al., 2021), to name a few.¹ As many of the consequences of a changing climate threaten humans' future on this planet (cf. IPCC, 2021), insights that the man-made causes of these processes (e.g., CO₂-emissions) need to be drastically reduced or even reversed have been gaining ground over the past few decades (cf. Decision 1/CP.21, Article 4 of the Paris Agreement²). Such a reduction requires encompassing societal, political, technological, and behavioural transformations, and the socio-ecological sphere borrowed the concept of tipping (back) from the natural sciences since "the consideration of tipping points helps to define that we are in a climate emergency" (Lenton et al., 2019, p. 592).

Tipping is generally understood as a situation in which a small perturbation can suffice to irreversibly push a system into a qualitatively different mode of operation due to strongly self-amplifying feedbacks

(Schellnhuber, 2010). According to Milkoreit et al. (2018, p. 10), social tipping is then a "point within an SES [socio-ecological system] at which a small quantitative change inevitably triggers a non-linear change in the social component of the SES, driven by self-reinforcing positive feedback mechanisms, that inevitably and often irreversibly lead to a qualitatively different state of the social system". Building on this research, Winkelmann et al. (2022) list four key distinctive features that characterize social tipping processes and differentiate it from natural tipping: human agency, social-institutional network structures, different spatial and temporal scales, and increased complexity. Overall, the social tipping concept is informed by "previous theoretical approaches, such as path dependency, theories of the policy process, policy feedback, the Granovetter model, norm changes, and technological transition approaches" but goes beyond as none of them "on their own [can] explain this type of transformational change" (Stadelmann-Steffen et al., 2021: 8).

A rich literature developed over the last couple of years that investigates social tipping relevant to sustainability. One of the core findings of this research is that social tipping can entail very different processes in many different areas. Farmer et al. (2019) list examples

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¹ For an assessment of potential climate tipping points, refer to Drijfhout et al. (2015).

² <https://unfccc.int/files/home/application/pdf/decision1cp21.pdf>.

from technology, finance, politics, and research & development. Lenton (2020) identifies, among others, several examples from the social system, which are related to changing norms or behaviours. Tàbara et al. (2018) include examples from governance, the energy, the socio-cultural, the technological, and the resource systems, as well as from the economy, while Otto et al. (2020a) concentrate on social tipping elements in energy and production storage, human settlements, financial markets, norms and values, education and information. Winkelmann et al. (2022) present instances like divestment from fossil fuels in financial markets, political mobilization, changes in social norms, and socio-technical innovation. One sphere that plays a rather implicit role in all these listings is the political sphere. Even though the latter sets the rules of the game through laws and regulations, tariffs and subsidies, public funding, and international treaties, especially in the realm of the environment (e.g., the Paris Accords, CO₂ trading certificates, R&D funds for green energy, zoning procedures for wind and solar power), few authors have so far focused on the role of the political arena in and for social tipping processes. This is particularly surprising since natural resources, but also the environment as a whole, are often understood as common good (cf. Barfuss et al., 2020) demanding for cooperation and collaboration (cf. Nyborg, 2020), and thus touching upon the concept of the tragedy of the commons (Ostrom, 1992), a concept well acknowledged in political science research.³ Keohane and Victor (2016), for instance, demonstrate the importance of national preferences and actor constellations for the potential success of different strategies of international negotiations in mitigating climate change. Besley and Persson (2022) moreover emphasize that different aspects of politics constrain feasible policies relevant for the green transition.

This is the starting point of our contribution, which not only emphasizes the political dimension's relevance to the analysis of social tipping, but also suggests ways to integrate this dimension into such analyses. We propose that the political sphere be conceptualized either as a *trigger* of social tipping, or as an *element that can tip itself*. Moreover, to capture the complexity that the interaction between structures, actors, and processes entails, we recommend a focus on the three elements of the political sphere: polity, politics, and policy. We demonstrate the usefulness of our conceptual refinements of the social tipping concept through conducting a comparative case study.

2. Social tipping and the political sphere

2.1. The political sphere and its relevance to social tipping

Many phenomena of interest with respect to social tipping initially seem non-political. For instance, CO₂-emissions are first and foremost the result of technology use and consumer behaviour. Similarly, the replacement of fossil energy requires renewable alternatives and actors' willingness to buy and use them. Accordingly, most scholarship on social tipping has focused on technology, finance, the economy, research & development, the energy sector, or the socio-technological system (Farmer et al., 2019; Lenton, 2020; Lenton et al., 2022; Otto et al., 2020a; Tàbara et al., 2018; Winkelmann et al., 2022). Table 1 presents a – non-exclusive – overview of how the political domain has so far been included in some of the seminal works on social tipping.

We can draw several conclusions from this table. First, while the idea that “the political” is relevant to social tipping is acknowledged, few studies explicitly include the political sphere into their analyses of social tipping. Indeed, Farmer et al. (2019) emphasize the “political system” and the importance of public support and political majorities for the adoption of the UK climate act. Similarly, Tàbara et al. (2018) mention that “timely and sharp policy interventions” may be needed to tip

social-ecological systems, and Winkelmann et al. (2022) illustrate the relevance of changes in public opinion with the FridaysForFuture example. Others refer to the political sphere in a less direct way, by discussing the role of socio-economic factors, social norms, and the social system at large. Second, the political sphere is mostly perceived as a context in which tipping may or may not occur. Hence, the political is most often treated as a side effect of social tipping or a framework condition for it. Third and finally, the “political” is often used in a rather broad and unspecific way, and/or is operationalized by a single aspect or indicator (e.g., policy support for one specific policy measure).

Building upon these insights, our main argument is that the current literature does not adequately conceptualize and measure the political sphere's influence on social tipping and thus underestimates not only its importance, but also its complexity (Stadelmann-Steffen et al., 2021). Indeed, we argue that the political sphere is one of the main reasons why social tipping does *not* occur (cf. Tàbara et al., 2018, p. 121) despite advanced technological solutions.⁴ The fact that many countries still deploy only negligible renewable energy infrastructure and the difficulty of politically implementing carbon taxation or other instruments to reach the goals of the Paris Agreement are the most obvious examples of this caveat. Therefore, we need a better understanding of the role the political sphere and its processes play in social tipping relevant to sustainability. The current literature has further overlooked the fact that the political may not only *trigger* social tipping (Stadelmann-Steffen et al., 2021) but may also *tip itself* into a new state, facilitating or instigating a tipping cascade. Moreover, we need a conceptualization of the political that adequately captures its complexity, especially considering existing references' failure to account for the numerous relevant elements the political consists of (see Table 1), and the inadvisability of reducing it to a single indicator.

2.2. Conceptualizing tipping in the political sphere

In a very illuminating example, Kopp et al. (2016, p. 348) illustrate tipping with a rail wagon of coal where the wagon stands for the tipping element and the tipping point would be “the point at which the wagon's physical dynamics commit it to falling on its side and emptying its contents. Foundry workers might provide the intended forcing to tip the wagon; on poorly constructed tracks, system noise might cause it to rock and perhaps to tip at a different point than intended.”

In the political sphere, however, it is often impossible to detect the exact point of tipping, which is why we suggest to understand social tipping as of a more procedural nature (Stadelmann-Steffen et al., 2021): Although a pro-environmental opposition party's landslide electoral victory, for example, might fundamentally alter the power structure and the political majority in a parliament, this alone is not a sufficient condition for social tipping as only political *action* can change a country's or a society's course. It is thus drastic policy change (e.g., a phase-out of fossil fuels, a climate resolution for all political decisions) *combined* with profound individual and collective attitudinal and behavioural change that we need for social tipping. Therefore, social tipping is seldom monocausal. While climate tipping processes can often be traced back to one central trigger – a rise in the mean global temperature – social tipping processes typically result from multiple causes (Winkelmann et al., 2022).

Furthermore, the political sphere should be understood as a complex network of actors – private and public, individual, and collective (e.g., parties, institutions, organizations) – that participate in governing the state, from the local to the transnational level. All actors are vested with agency (Otto et al., 2020b; Wiedermann et al., 2020), which entails foresight and the capacity to deliberately collaborate to change the

³ Other authors (e.g., Aklin and Mildenerger, 2020) refute the idea of climate change policy to be a collective action problem and argue to rather understand it as a distributive conflict.

⁴ See also Ehret et al. (2022) for an experiment on how group identities can undermine social tipping after an intervention in a highly partisan context or Nyborg (2020).

Table 1
The political dimension in previous social tipping publications.

	Reference to the political dimension	Political dimension as ...	Examples	(Empirical) measurement
Centola et al. (2018)	Social convention	Not directly mentioned	“When a committed minority reaches a critical group size—commonly referred to as a “critical mass”—the social system crosses a tipping point”.	Experimental approach: artificially created system of evolving social norms
Farmer et al. (2019)	The political system	Context	Political mobilization as a process leading to tipping	Public support and adoption; power of minorities vs. majorities
Kopp et al. (2016)	Indirectly as social tipping element	Not directly mentioned	Public opinion and policy change, behavioural adaptation, migration, conflict	–
Lenton (2020)	Indirectly as social system	Not directly mentioned	World views, norms, behaviour, revolution	–
Otto et al. (2020a)	Indirectly as norms and values system	Not directly mentioned	Norms and values	–
Tàbara et al. (2018)	“The required capacities, conditions and potential policy interventions which could eventually lead to the emergence of positive tipping points in various social-ecological systems to address the 2–1.5 °C policy target.” Part of the socio-ecological system.	Context	Governance: “civic participation if fully developed, with fair multi-level coordination and international cooperation in line with shared, integrated and long-term sustainability orientation.”	–
Winkelmann et al. (2022)	The political system	Social tipping element	Political mobilization; norms and behaviour; activism (FridaysForFuture) and public opinion change within the European political system	Public opinion changes in opinion polls: environment as the most important problem

Note: This non-exclusive list serves to exemplify our argument that the political dimension only plays minor role in most current publications. Alphabetical ordering by author names.

course of the future. Each actor comes with its own set of preferences and degree of power and tries to influence the political decision-making and policy implementation processes in a way consistent with these preferences. The rules of the game (e.g., the country’s constitution, code of conduct, laws, regulations, and treaties) shape the playing field and the actions actors can take. Violations might be sanctioned (rule of law) or overlooked (corruption). Within a network, opinions, information, norms, behaviours, values, and ideas might spread and cause for the network to tip (Otto et al., 2020a; Otto et al., 2020b; Winkelmann et al., 2022). The networks themselves are not stable as connections might break or form anew (e.g., through polarization) and new actors might enter the arena, thus altering the network and its power structure. Networks can also change depending on their topic, with some actors being part of multiple networks (e.g., parties) and others only being part of one or two networks (e.g., an NGO).

Researchers might therefore be most interested in identifying (mathematically) positive feedback effects capable of instigating (mathematically) positive social tipping dynamics in the political sphere, which might in turn hinder (normatively negative) natural tipping (Lenton et al., 2021). Moreover, and like existing studies have already explained (Winkelmann et al., 2022), natural and social tipping differ in their underlying time frames: they typically are much shorter in socio-technological systems. Humans usually think and act in rather short spans of days, months, years, or maybe decades (e.g., the business year, electoral cycles, a generation), whereas natural processes (e.g., evolution) might take hundreds or thousands of years. These different time horizons are a major caveat in mitigating and adapting to climate change, because even the 2050 zero-net-emission goal is too late for some and too soon for others, while the most drastic consequences of failing to achieve it (e.g., rising sea levels, loss of biodiversity) will mostly impact future generations (IPCC, 2021). They are thus rather abstract – or even irrelevant – to many today.

To sum up, in the political sphere, tipping is characterized by multidimensional, multiplicative, and non-linear processes and by different states of the system that may be less stable than the tipping literature suggests. These characteristics, as we will argue, also explain why profound societal and political transformations are often difficult to achieve and why, in our view, previous research underestimates the relevance of the political. Adding the political sphere to the analysis of social tipping therefore introduces another level of complexity.

Nevertheless, doing so is a necessary step if we are to fully explore the potential of the concept of social tipping in the context of sustainability. We therefore make two propositions related to the conceptualization of the political sphere in studies on social tipping:

- 1) *Specifying the role of the political sphere: The political as a trigger of social tipping vs. the tipping of the political sphere.* Conceptualizing the political in studies on social tipping requires that we first specify its role. Two different perspectives for focusing on the political sphere through a social tipping lens stand out depending on one’s specific research interests. The first resembles previous approaches (Farmer et al., 2019; Tàbara et al., 2018) and conceptualizes the political sphere as a context that determines both the playing field and the rules of the game. Conversely, the second perspective envisions the political more narrowly as a part of “the system” that may tip itself and trigger tipping cascades (Stadelmann-Steffen et al., 2021). As such, the political sphere is treated like any other tipping element. We contend that previous conceptualizations have neglected this second perspective, which conceives the political sphere as the core of social tipping and should be taken into consideration by future research (see (2) below).
- 2) *Capturing political multidimensionality: policy, politics, polity.* As we have mentioned above, existing studies often acknowledge that political factors are important to understand social tipping. However, even if they explicitly integrate the political, these studies often do so by utilizing only one single variable or concept, such as political support, political mobilization, or a specific policy. Yet, to adequately conceptualize the political sphere and its role in social tipping, we need to better integrate its multidimensionality and complexity. To account for these particular challenges, political scientists often distinguish between three elements (Treib et al., 2007): *polity* (form: e.g., political system, institutions, constitution), *politics* (process: e.g., political decision making, elections, direct democracy), and *policy* (content: e.g., goals, interests, solutions). In our view, employing this three-fold distinction is also useful as far as social tipping is concerned. Research designs and indicators’ operationalizations greatly depend on one’s research question and on the perspective on the political sphere (see (1) above). In some cases, it might be reasonable to only focus on one or two of these elements. However, and particularly when we focus on the tipping of the

political system, it is highly likely that all three - polity, politics, and policy - need to be incorporated. Several examples attest to this.

First, assume that we are interested in social tipping towards a new “state” of carbon-neutrality in which carbon taxation has become a widely used and accepted policy instrument for climate change mitigation. In an empirical research design, we would use a dependent variable measuring, for example, support (politics) for a political content (policy) in a given political context (polity). Another example could be the interdependence between the political decision-making process, a policy’s content, and the electoral cycle. The tipping of political majorities – and ultimately – leadership is one of the core principles of democracy, and a peculiarity of the political sphere. Legislative periods therefore often critically affect political actors’ time horizons and thus hinder – or facilitate – political progress. Take the ruptures that characterize the transition from a Democrat to a Republican US-president, or vice versa, when the new administration tries to reverse decisions taken by the previous government as quickly as possible, such as leaving and re-joining the Paris Accords. Furthermore, direct democratic instruments might turn citizens into powerful actors capable of vetoing or initiating political decisions even between elections (Stadelmann-Steffen, 2011). This makes political decisions reversible in principle. Yet, the system might not ‘tip back’ into its exact previous state. If governments decide to phase-out nuclear power, neither the energy system, nor the economy or society will be identical to what they used to be before nuclear power was adopted some decades ago.

Finally, the volatility of political issues, another peculiarity of the political, can also be used to illustrate the benefits of incorporating all three elements of the political sphere. Topics might suddenly (re-)appear on the political agenda because of extreme events (e.g., a terrorist attack, a natural disaster like a flood, drought, or an out-of-control wildfire) or long-lasting crises (e.g., major economic and financial crises, a pandemic, a war). Such events or crises might change the political landscape and open windows of opportunity for (fundamental) policy change, e.g., the phase-out of nuclear power or the substitution of carbon fuels (Meijerink, 2005). They can, thus, serve as triggers for tipping processes, as they may prove the need to act fast (Stadelmann-Steffen and Thalmann, 2021).⁵

3. A comparative case study: the nuclear phase-out in Germany and Switzerland

While the previous section proposed a refined conceptualization of the political sphere for social tipping, the concept still needs to be translated into feasible and valid research designs and operationalizations to enable empirical analysis (Stadelmann-Steffen et al., 2021). Hence, to illustrate this translation and the empirical benefits of putting the political at the centre of social tipping research, we present a comparative case study on nuclear phase-outs in Germany and Switzerland distinguishing tipping dynamics associated to the trias of policy, polity, and politics. The main aim is to show in how far the detailed consideration of the three political dimensions can improve our understanding of whether, how, and why the two political systems have tipped towards nuclear phase-out.

To analyse the processes and dynamics related to the phase-out decisions in the two countries, we developed an analysis grid building on the works by Lange et al. (2013) and Treib et al. (2007). Most important, this grid specifically distinguishes between politics, polity and policy. Moreover, and in order to translate the three dimensions into empirically measurable concepts, we have identified indicators within each dimension to assess whether and where tipping dynamics have occurred. This grid (Table 2) was then filled with publicly available information

from various sources (e.g. governmental publications, newspapers, reports; see Appendix) to allow for comparisons between and across dimensions and countries. As we will argue in the following, the case of nuclear phase-out in Germany and Switzerland, analysed from a social tipping perspective and considering the political as multidimensional concept, can be characterized as a tipping of the political sphere itself. Additionally, the distinction between the different dimensions of the political enables us to show that the political tipping in our case study involved at least two of the three political dimensions (policy and politics) and was moreover heavily shaped by the polity dimension. In what follows, we report on the analysis and the findings that lead us to these conclusions (see Supplementary Material for a more detailed version, including relevant sources, of Table 2).

3.1. Tipping at the policy level

On March 11, 2011, an earthquake and the resulting tsunami killed thousands of Japanese people, devastated a whole area and initiated the Fukushima Daiichi nuclear disaster. With memories of the Chernobyl nuclear disaster in 1986 still vivid in the European public, the after-shocks were felt half-way around the globe and led to profound and encompassing changes – tipping – in the political system. In Germany and Switzerland, the catastrophe acted as an external shock (Stadelmann-Steffen et al., 2021) triggering the decision to phase-out nuclear energy. This decision has far-reaching consequences, in particular for a highly industrialized country like Germany, and thus the verdict to shut down several nuclear power plants immediately and phase-out the others as soon as possible can be interpreted as tipping in the policy realm. The Swiss example may be less clear in that respect, as the phase-out decision took longer, and only included a stepwise phase-out effectuated not through the shut-down of running plants but rather by prohibiting their replacement. Yet, we argue that the Swiss case can also be considered as tipping of the political sphere as the decision is encompassing and was the result of a political majority having tipped towards a future without nuclear energy, while before the country had explicitly rejected a nuclear phase-out several times.⁶

However, to better understand and characterize the tipping dynamics towards a nuclear phase-out, we proceed by incorporating the politics and the polity dimension.

3.2. Politics – the tipping majority

The political actors in Germany, first and foremost the federal CDU-FDP-government, decided to phase-out nuclear power by 2022 only days after the catastrophe, and at the same time immediately shut down eight nuclear power plants. This came only months after the very same government had decided to continue building on nuclear power. This rapid process was not least influenced by the historic defeat of the CDU government in the state elections of Baden-Württemberg and the resulting first ever Green state prime minister. The Bundestag as well as the second chamber, the Bundesrat, confirmed the phase-out decision only weeks later. Large parts of the German population welcomed this verdict. An ethics committee consisting of representatives from politics, the economy, unions, the churches, and scientists was nominated by the government to attend the process. Overall, a broad consensus was reached across the political spectrum, but also within the public. The only notable opposition was several major energy companies which turned to the Federal Constitutional Court, but the judges confirmed the governmental. Yet, they ruled for the companies to be reimbursed. Fukushima thus served as an external shock (Stadelmann-Steffen et al., 2021) that tipped the German governing majority into phasing-out nuclear power in a comparatively short amount of time, although the

⁵ For a more general comparison of various established approaches of change and social tipping, refer to Stadelmann-Steffen et al. (2021).

⁶ In particular popular initiatives requesting nuclear phase-out in the years 1984, 1990, 2003, 2016 (www.swissvotes.ch).

Table 2
Analysis grid – social tipping towards a nuclear phase-out.

	Germany	Switzerland
<i>Political processes/actor constellations (politics)</i>	Government, parliament, federal court, public, energy companies, various stakeholders	Government, parliament, citizens, various stakeholders
Actors (public-private)	Which actors are involved?	
Coalition pattern	Who is in favour or against? Who forms the relevant majority for tipping?	Support: Greens, Social Democrats Against: Swiss People Party (SVP)
Power relations/opinion leader	Who is opinion leader? Who triggers the process?	Tipping: Government, CVP, population Federal Council, SVP
<i>Institutional structures/properties (policy)</i>	Informal and formal rules (Who decides and how?)	Majority rule in parliament, vote on governmental proposal, popular referendum
Institutional architecture	Veto points (Direct democracy, federalism, EU politics)	Parliament, Citizens (direct democracy)
<i>Policy content/policy instruments (policy)</i>	What phase-out exactly?	Gradual phase-out by not replacing existing power plants that reach end of life cycle
Policy formulation	Time horizon? Different stages?	Stepwise, no strict deadline

Annotation: Based on Lange et al. (2013) and Treib et al. (2007). Sources for case-study information can be found in the Appendix.

foundation for this decision had been laid by a well-established anti-nuclear movement that had been protesting the technology for decades.

In Switzerland, Fukushima also prompted the government to suggest a stepwise nuclear phase-out, yet in contrast to Germany, power plants should not be shut down immediately, but rather not be replaced at the end of their service life. This suggestion was included as one measure into the Energy Strategy 2050 – which more generally set up Switzerland’s transition from fossil and nuclear energy to renewable energy sources – and was then decided upon through the regular decision-making process involving numerous actors on different levels of state. Finally, in 2017, the public had the last word and accepted the strategy by referendum launched by the SVP. The decision thus took much longer than in Germany and involved the public as a veto player. Also, unlike Germany, there was a stronger opposition within parliament, although in the end the necessary majorities for a “Swiss-style compromise” could be achieved.

When comparing the two cases and from a tipping perspective, one major difference between Germany and Switzerland is related to the idea of criticality (Winkelmann et al., 2022): Germany was already in a “critical state”, i.e., close to a situation where the system would tip towards majority support for nuclear phase out as the public had been very sceptical towards nuclear energy, not least since 1986. Hence, the Fukushima disaster literally added the necessary piece of coal to let the majority tip towards full and rapid phase-out. This was different in Switzerland, where opponents and supporters of the nuclear phase-out had maintained a non-majority but stable balance for years.

3.3. Polity – the institutional context

Finally, the differences in the politics dimension, namely the varying actors involved, and the varying speed of decision-making largely depend on the polity dimension, which exhibits important differences between the two countries. The formal rules in both countries are defined by the respective constitutions. Both assign nuclear energy to the federal level, but both countries also have the subnational level involved, not least through the second chamber of Parliament. Furthermore, in the regular decision-making processes, other interests must be heard, and interest groups try to influence the process at all stages. The direct-democratic system of Switzerland has the public as additional veto point, either when laws and regulations need to be approved top-down or when initiatives are initiated from the bottom-up (Stadelmann-Steffen, 2011). For Germany, the EU is another important player as Brussels’ rules and regulations determine the room for manoeuvre in many policy areas, for instance through environmental protection measures culminating in the European Green Deal⁷ that strives to reduce the EU’s net greenhouse gas emissions by at least 55% by 2030. In the aftermath of Fukushima, the EU ordered all European nuclear power plants to undergo a stress test and one year later published an action plan to increase the safety of these power plants (Kiyar and Wittneben, 2012).

The institutional differences imply that for the political majority to tip towards a nuclear phase-out, varying central actors can be identified. In Germany, it was mainly the CDU-FDP government coalition, which abruptly changed its position on that issue. This tipping was much more remarkable than the parliament’s backing of this decision, because in the German parliamentary system, the government usually holds a parliamentary majority. In Switzerland, conversely, crucial compromises and case-wise coalitions need to be formed in parliament. Left-green forces that mainly supported the energy transition and therefore with nuclear phase-out at that point did not have a majority in the Swiss parliament. Hence, the parliamentary majority only tipped because not only the Swiss Christian Democrats but also parts of the FDP supported

⁷ https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en.

the energy strategy in the final vote.

In both countries, the institutional set-up provided one crucial veto player with the power to prevent tipping. In Germany, this was the Federal Constitutional Court that needed to evaluate whether the Atomic Energy Act was compatible with the constitution. This corresponds to the prototypical separation of powers in consensual political systems. In the specific case, the Constitutional Court identified some problems but decided that the rapid nuclear phase-out was largely in accordance with the constitution. The court's ruling was, thus, a central last piece contributing to the binding phase-out decision in Germany. In Switzerland, the main veto point is the citizens who, at the ballot, have the final say in important decisions such as a nuclear phase-out (Stadelmann-Steffen, 2011). Between 1984 and 2016, the Swiss citizenry had voted six times on (different variants) of a nuclear phase-out.⁸ Except for a ten-year moratorium for the construction of new nuclear power plants in 1990, the population always decided against the phase-out. This shows that the acceptance of the Energy Strategy 2050 and therewith the (stepwise) nuclear phase-out importantly depended on a tipping of the population majority in the 2017 vote.

3.4. Discussion – the tipping of the political towards nuclear phase-out

To sum up, we find clear indications that Fukushima as an external shock led to encompassing change in two of the three political dimensions in both countries under study – only the polity dimension, the rules of the game, had not changed. Consequently, in both countries the political sphere itself tipped to a new state characterized by a political majority in favour of a nuclear phase-out. Indeed, with the decision to phase-out nuclear energy, both countries underwent drastic *policy* changes that were only possible because some central actors (i.e., the *politics* dimension) changed their preferences and behaviours and thus formed new coalitions, thereby altering the power structure and the underlying network. The political system tipped from supporting an energy system that relies on nuclear power to one that will be based on alternative energy sources and these tipping dynamics can be observed in the different political dimensions.

In the present case study, we used publicly accessible governmental statements, reports, and media information as data sources to retrace the course of events and what we presented here is just a short summary of the material collected (see Appendix and Supplementary Material for a list of sources). While in this study, we considered the political decision to phase out as the tipping element, the effects of the decisions can only be measured in the future, amongst others, through the energy mix. In Germany, where the last nuclear power plant is supposed to shut down in late 2022,⁹ this might be the case rather soon, the Swiss numbers might look different from the Germans for a while as the phase-out follows a different trajectory. This difference can become consequential: With the latest taxonomy decision taken in Brussels that defines nuclear power as 'green' due to it being CO₂-neutral, and in combination with high inflation and energy gas prices, the discussions to revoke or slow down the nuclear phase-out are in full swing. In that respect, the potential to reverse the tipping process may largely depend on whether and how far the phase-out has already been implemented. But even if the phase-out process was reversed, the system would not tip back into the exact previous state of pre-Fukushima.

4. Conclusion and Policy Implications

This paper argued that research on social tipping relevant for sustainability has so far often neglected the political sphere, despite the latter's major role in setting the rules of the game or defining the playing

field. We suggested that the political can be integrated into the study of social tipping in two ways. On the one hand, it can be conceived as relevant context in which social tipping occurs and which affects how and when tipping happens, as has been done in previous studies. On the other hand, however, we also emphasized that it may be valuable to consider the potential tipping of the political system itself. The latter perspective is highly relevant, given that the political implementation of new technologies and measures is one of the main challenges on the way to reaching the Paris goals.

We have further demonstrated that the political sphere encompasses more than green parties' vote shares or popular attitudes on climate change – it is a highly complex and dynamic multilevel network of individual and collective actors vested with agency, holding specific sets of preferences (*politics*), and deciding on political measures and contents (*policy*) within a specific political context (*polity*). Electoral cycles often influence the political decision-making process, which might make agreeing upon and implementing long-term policies difficult. Furthermore, topics might appear and disappear from the political agenda on short notice (e.g., because of a disaster or war) and thus change actors' – and, sometimes, even the network's – preference order. The underlying processes are thus non-linear and might reinforce one another towards (normatively positive or negative) tipping – or resilience. The potential for rapid transformation is thus often small, as individuals, societies and organizations are loath to change (e.g., Nyborg, 2020; Rosenbloom et al., 2019; Stadelmann-Steffen et al., 2021; Wiesner et al., 2019). However, windows of opportunity for rapid societal transformations might open unexpectedly (e.g., Fukushima).

Using the example of the political decisions to phase-out nuclear energy in Germany and Switzerland, we exemplified the benefit of explicitly considering the tipping of the political system. In addition, we presented the advantages of applying a multi-dimensional perspective. In the cases under investigation, the *policy* dimension helped us to describe the nature of the tipping. While Germany decided to shut-down all nuclear power plants until the end of 2022, the phase-out decision in Switzerland was less drastic. This might raise the question of whether and when the phase-out will actually be implemented at the technical level. However, we argued that from a political point of view, the nature of the Swiss decision can indeed be considered as tipping. This is then illustrated in view of the *politics* dimension. In both countries, we showed how actor positions and, thus, coalitions changed and enabled the political majority to tip towards supporting a nuclear phase-out. Eventually, taking the *polity* dimension into account helped us to show why and how different actors could be identified as crucial for the tipping to happen in the two countries. Overall, the example demonstrates that had we focused on the *policy* dimension only, i.e., on the visible change in regulating nuclear energy, we would have missed the multidimensional processes and dynamics corresponding to a tipping of the political sphere, and maybe – especially in the Swiss case and given the less abrupt nature of the phase-out – we would not have been able to qualify the phase-out as tipping at all.

We conclude that future studies should place more emphasis on the relevance of the political sphere for social tipping dynamics, and the value of the social tipping concept for political processes. While we have illustrated our multidimensional approach using the example of a qualitative case study, we argue that it is in fact open to a broad range of quantitative and qualitative methodological designs and tools. Our framework is therefore suitable for all methods that allow for measuring or analysing the role of the political sphere along the three dimensions as well as their interactions, and to consider a time perspective. Furthermore, more efforts are necessary to analyse whether majorities within parliaments, institutions (e.g., the EU), or the public itself are necessary and/or sufficient conditions for social tipping, or whether we need specific combinations of actors and framework conditions for tipping to occur in the political sphere. Comparative approaches could, moreover, help overcome the challenge of data availability that researchers in the social sciences often encounter.

⁸ See www.swissvotes.ch.

⁹ This decision was still valid at the time of writing although three nuclear power plants will operate until April 2023 due to high energy prices.

In more practical terms, our study demonstrates that policymakers should not only focus on how the technological and economic sphere can (better) contribute to necessary and rapid changes in climate change mitigation, but should also more specifically consider the role the political has in this process, not only as a framework condition, but as an inherent element that needs to tip or be tipped.

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CRedit authorship contribution statement

Christina Eder: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing. **Isabelle Stadelmann-Steffen:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing.

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.

Data availability

Data is included in the Appendix and the Supplementary Materials.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.enpol.2023.113529>.

Appendix B

Sources used for the case studies on nuclear phase-out in Germany and Switzerland (Please refer to Supplementary Material for a more detailed table).

Germany

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Actors (public-private).

- BASE. Der Atomausstieg in Deutschland. https://www.base.bund.de/DE/themen/kt/ausstieg-atomkraft/ausstieg_node.html
- Kiyar, D., & Wittneben, B. F. (2012). Nuclear energy in the European union after Fukushima: Political and economic considerations. *CESifo DICE Report*, 10(3), 9–15.

- BMUV. Der Europäische Stresstest. <https://www.bmuv.de/themen/atomenergie-strahlenschutz/nukleare-sicherheit/fukushima-folgemassnahmen/eu-stresstest>
- Stresstests in Deutschland » im Dokument „Fachbericht zum Jahrestag der Nuklearkatastrophe in Japan“. <https://www.base.bund.de/SharedDocs/Downloads/BASE/DE/broschueren/bfe/fukushima-10-jahre-fachbericht.html>
- BMUV. Abschlussbericht der Ethikkommission “Sichere Energieversorgung”. <https://www.bmuv.de/download/deutschlands-energie-wende-ein-gemeinschaftswerk-fuer-die-zukunft>
- BMUV. Urteil zum Atomausstieg. <https://www.bmuv.de/faqs/urteil-zum-atomausstieg>
- Bundesregierung. Gemeinsame Pressemitteilung vom 05.03.21. <https://www.bmwi.de/Redaktion/DE/Pressemitteilungen/2021/03/20210305-bundesregierung-und-energieversorger-verstaendigen-sich-auf-finanziellen-ausgleich-und-beilegung-aller-rechtsstreitigkeiten-zum-atomausstieg.html>
- Süddeutsche Zeitung. Anti-Atom-Bewegung mobilisiert 250.000 Menschen. <https://www.sueddeutsche.de/politik/bundesweite-proteste-anti-atom-bewegung-mobilisiert-zehntausende-1.1077642>

Interaction processes/relations.

- Landeszentrale für politische Bildung Baden-Württemberg. Die Energiewende 2011. <https://www.lpb-bw.de/energiewende>
- Fachbericht zum Jahrestag der Nuklearkatastrophe in Japan (S. 97, 99). <https://www.base.bund.de/SharedDocs/Downloads/BASE/DE/broschueren/bfe/fukushima-10-jahre-fachbericht.html>
- 117. Sitzung des Deutschen Bundestages. Endgültiges Ergebnis der Namentlichen Abstimmung Nr. 1. https://www.bundestag.de/resource/blob/191952/eef51099a8fda21591f61c5f43cd6ec7/20110630_17_6070-data.pdf
- Die Zeit. Parlament will Atomausstieg besiegeln. <https://www.zeit.de/politik/deutschland/2011-06/Atomausstieg-Beschluss-Bundestag>
- Deutscher Bundestag. Abstimmung über Atomausstieg und Energiewende. Deutscher Bundestag - Abstimmung über Atomausstieg und Energiewende
- Deutscher Bundesrat. Das Ende einer langen Debatte. <https://www.bundesrat.de/SharedDocs/texte/11/20110714-energiewende-2.html>
- BMUV. Urteil zum Atomausstieg. <https://www.bmuv.de/faqs/urteil-zum-atomausstieg>
- Bundesregierung. Gemeinsame Pressemitteilung vom 05.03.21. <https://www.bmwi.de/Redaktion/DE/Pressemitteilungen/2021/03/20210305-bundesregierung-und-energieversorger-verstaendigen-sich-auf-finanziellen-ausgleich-und-beilegung-aller-rechtsstreitigkeiten-zum-atomausstieg.html>

- BASE. Der Atomausstieg in Deutschland. https://www.base.bund.de/DE/themen/kt/ausstieg-atomkraft/ausstieg_node.html

Division of power.

- Bundestag. Zusammensetzung der Bundeskabinette. https://www.bundestag.de/resource/blob/196242/1e3a0ca3a780d0595479b8c53b1e1857/Kapitel_06_02_Zusammensetzung_der_Bundeskabinette_-_Namensliste-data.pdf
- 117. Sitzung des Deutschen Bundestages. Endgültiges Ergebnis der Namentlichen Abstimmung Nr. 1. https://www.bundestag.de/resource/blob/191952/eef51099a8fda21591f61c5f43cd6ec7/20110630_17_6070-data.pdf
- Deutscher Bundestag. Bundestagswahlergebnisse seit 1949. https://www.bundestag.de/parlament/wahlen/ergebnisse_seit1949-244692
- Deutscher Bundesrat. Archiv – Zusammensetzung des Bundesrates. https://www.bundesrat.de/SharedDocs/bilder/DE/galerien/stimmverteilung-br/zusammensetzung-br.html;jsessionid=BF702EE640170988DA86CED1A6421EF4.1_cid382?nn=4353098

POLITY

Institutional structures/properties.

- BMUV. Verfassung und Gesetze. <https://www.bmuv.de/themen/atomenenergie-strahlenschutz/nukleare-sicherheit/rechtsvorschriften-technische-regeln-und-regelungen/verfassung-und-gesetze>
- Deutscher Bundestag. Die Gesetzgebung des Bundes. https://www.bundestag.de/parlament/aufgaben/rechtsgrundlagen/grundgesetze/gg_07-245138
- BMI. Gesetzgebungsverfahren. <https://www.bmi.bund.de/DE/themen/verfassung/gesetzgebung/gesetzgebungsverfahren/gesetzgebungsverfahren-node.html>

Institutional architecture.

- SRF. EU-Kommission stuft Gas- und Atomkraft als nachhaltig ein. <https://www.srf.ch/news/international/umstrittene-eu-klimaplaene-eu-kommission-stuft-gas-und-atomkraft-als-nachhaltig-ein>
- BMUV. 12 Punkte für die Vollendung des Atomausstiegs. https://www.bmuv.de/fileadmin/Daten_BMU/Download_PDF/Nukleare_Sicherheit/12_punkte_atomausstieg_bf.pdf
- BMUV. Stellungnahme der Bundesregierung zur EU-Taxonomie. <https://www.bmuv.de/download/stellungnahme-der-bundesregierung-zur-eu-taxonomie> und https://www.bmwk.de/Redaktion/DE/Downloads/S-T/stellungnahme-bundesregierung-taxonomie.pdf?__blob=publicationFile&v=8

POLICY

Policy content/policy instruments.

- BMUV. Gesetze zur Änderung des Atomgesetzes. <https://www.bmuv.de/themen/atomenenergie-strahlenschutz/nukleare-sicherheit/gesetze-zur-aenderung-des-atomgesetzes>

- Bundesgesetzblatt Jahrgang 2011. Dreizehntes Gesetz zur Änderung des Atomgesetzes. https://www.bgbl.de/xaver/bgbl/start.xav?startbk=Bundesanzeiger_BGBL%26start=//%5b@attr_id=%27bgl111s1704.pdf%27%5d#_bgbl_%2F%2F*%5B%40attr_id%3D%27bgl111s1704.pdf%27%5D_1665999959237

Policy implementation.

- Fachbericht zum Jahrestag der Nuklearkatastrophe in Japan (S. 94–102). <https://www.base.bund.de/SharedDocs/Downloads/BAS/DE/broschueren/bfe/fukushima-10-jahre-fachbericht.html>
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Switzerland

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Actors (public-private).

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Interaction processes/relations.

- Eidgenössisches Departement für Umwelt, Verkehr, Energie und Kommunikation. Bericht über die Ergebnisse der Vernehmlassung zum ersten Massnahmenpaket der Energiestrategie 2050 (S. 16). <https://www.admin.ch/gov/de/start/dokumentation/medienmitteilungen.msg-id-50123.html>
- Année politique Suisse. Energiestrategie 2050. <https://anneepolitique.swiss/prozesse/19708-strategie-energetique-2050>
- Schlussabstimmung Ständerat. Energiestrategie 2050. <https://www.parlament.ch/de/ratsbetrieb/amtliches-bulletin/amtliches-bulletin-die-verhandlungen?SubjectId=38393#votum2>
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Division of power.

- Die Bundesversammlung - Das Schweizer Parlament. Die Fraktionen der Bundesversammlung seit der 46. Legislaturperiode. <https://www.parlament.ch/de/%C3%BCber-das-parlament/archiv/archiv-fraktionen>
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- Année politique Suisse. Atomausstiegsinitiative. <https://anneepolitique.swiss/prozesse/55930>
- UVEK. Volksinitiative « Für den geordneten Ausstieg aus der Atomenergie ». <https://www.uvek.admin.ch/uvek/de/home/uvek/abstimmungen/atomausstiegsinitiative.html>
- Année politique Suisse. Energiestrategie 2050 (S. 10–11). <https://anneepolitique.swiss/prozesse/19708-strategie-energetique-2050>

POLICY

Policy content/policy instruments.

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Policy implementation.

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- UVEK. Chronologie zur Energiestrategie 2050. <https://www.uvek.admin.ch/uvek/de/home/uvek/abstimmungen/abstimmung-zum-energiesgesetz/chronologie-und-grafiken.html>

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