Explaining Advocacy Coalition Change with Policy Feedback

Originally published in:
Policy Studies Journal 48(4), https://doi.org/10.1111/psj.12365

Funding acknowledgement:
- Opening the black box of the co-evolution of policy and technology in the energy sector ()

PSJ
POLICY STUDIES JOURNAL

Policy Studies Journal, Vol. 48, No. 4, 2020

Explaining Advocacy Coalition Change with Policy Feedback

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Despite the prominence of exogenous factors in theories of policy change, the precise mechanisms that link such factors to policy change remain elusive: The effects of exogenous factors on the politics underlying policy change are not sufficiently conceptualized and empirically analyzed. To address this gap, we propose to distinguish between truly exogenous factors and policy outcomes to better understand policy change. Specifically, we combine the Advocacy Coalition Framework with policy feedback theory to conceptualize a complete feedback loop among policy, policy outcomes, and subsequent politics. Aiming at theory-building, we use policy feedback mechanisms to explain why advocacy coalitions change over time. Empirically, we conduct a longitudinal single case study on policy-induced technological change in the German energy subsystem, an extreme case of policy outcomes, from 1983 to 2013. First, using discourse network analysis, we identify four patterns of actor movements, explaining coalition decline and growth. Second, using process tracing, we detect four policy feedback mechanisms explaining these four actor movements. With this inductive mixed-methods approach, we build a conceptual framework in which policy outcomes affect subsequent politics through feedback mechanisms. We develop propositions on how coalition change and feedback mechanisms explain four ideal-typical trajectories of policy change.

KEY WORDS: policy change, technological change, energy transition

尽管外源性因素在政策变化理论中存在重要性，但将这类因素与政策变化进行连接的精确机制还难以理解：外源性因素对政策变化背后的政治所产生的效果还没有被完全地概念化，也没有经过实证分析。为填补这一研究空白，作者提出区分真实外源性因素和政策结果，以更好地理解政策变化。特别地，作者结合倡议联盟框架（*ACF*）和政策反馈理论，以在政策、政策结果、后续政治之间概念化一个完整的反馈环。致力于理论建设，作者使用政策反馈机制，解释为何倡议联盟会随时间发生变化。实证上，作者实施了一项纵向单一案例分析，研究德国能源子系统中由政策引起的技术变革，它是一项关于*1983*年至*2013*年政策结果的极端案例。第一，通过话语网络分析，作者识别了行动者进展的四种模式，解释联盟的减少和增加。第二，通过过程跟踪，作者探测出四种诠释行动者进展的政策反馈机制。通过这一对不同结果进行归纳的方法，作者建立一项概念框架，政策结果能从中通过反馈机制来影响后续政治。就联盟变化和反馈机制如何能解释四种关于政策变化的理想-典型轨迹，作者提出了建议。

政策变化，技术变革，能源转型

doi: 10.1111/psj.12365

A pesar de la importancia de los factores exógenos en las teorías del cambio de políticas, los mecanismos precisos que vinculan dichos factores con el cambio de políticas siguen siendo esquivos: los efectos de los factores exógenos en la política subyacente al cambio de políticas no están suficientemente conceptualizados y analizados empíricamente. Para abordar esta brecha, proponemos distinguir entre factores verdaderamente exógenos y resultados de políticas para comprender mejor el cambio de políticas. Específicamente, combinamos Advocacy Coalition Framework (ACF) con la teoría de retroalimentación de políticas para conceptualizar un ciclo completo de retroalimentación entre políticas, resultados de políticas y políticas subsiguientes. Con el objetivo de construir una teoría, utilizamos mecanismos de retroalimentación de políticas para explicar por qué las coaliciones de defensa cambian con el tiempo. Empíricamente, realizamos un estudio de caso único longitudinal sobre el cambio tecnológico inducido por políticas en el subsistema de energía alemán, un caso extremo de resultados de políticas, de 1983-2013. Primero, utilizando el análisis de la red del discurso, identificamos cuatro patrones de movimientos de actores, que explican el declive y el crecimiento de la coalición. En Segundo lugar, utilizando el rastreo de procesos, detectamos cuatro mecanismos de retroalimentación de políticas que explican estos cuatro movimientos de actores. Con este enfoque inductivo de métodos mixtos, construimos un marco conceptual en el que los resultados de las políticas afectan las políticas posteriores a través de mecanismos de retroalimentación. Desarrollamos proposiciones sobre cómo el cambio de coalición y los mecanismos de retroalimentación explican cuatro trayectorias ideales de cambio de políticas.

PALABRAS CLAVE: cambio de política, cambio tecnológico, transición energética

1. Introduction

The dichotomy between exogenous and endogenous factors of policy change plays a prominent role in influential theoretical accounts of policy change (Cashore & Howlett, 2007). While *minor* policy change is often attributed to endogenous factors, exogenous factors are often considered necessary conditions for *major* policy change (Baumgartner et al., 2009; Hall, 1993; Kingdon, 1995; Sabatier, 1988). For example, in the Advocacy Coalition Framework (ACF), exogenous (or external) factors are considered drivers of change in otherwise stable policy subsystems, thereby enabling policy change (Sabatier, 1988). Despite the prominence of external factors in explaining policy change, the precise *mechanisms* that link exogenous factors to policy change remain elusive. Consequently, empirical applications underline the sudden, unforeseeable character of exogenous factors, which are described as either "crisis," "perturbation," or "shock" (Nohrstedt & Weible, 2010). Arguably, this development has somewhat obscured that exogenous factors can also change over a long(er) period and, most importantly, that they can result from previously made policy decisions (Schmidt & Sewerin, 2017). To overcome this conceptual gap, we suggest to reassess the nature of exogenous factors and empirically investigate their impact on the politics underlying policy change. Based on the ACF, we conceptualize politics as the relative strength and structure of different advocacy coalitions in a given policy subsystem. In brief, the ACF suggests that policy change is the consequence of changes in advocacy coalition structures within policy subsystems (Fischer, 2014; Sabatier,

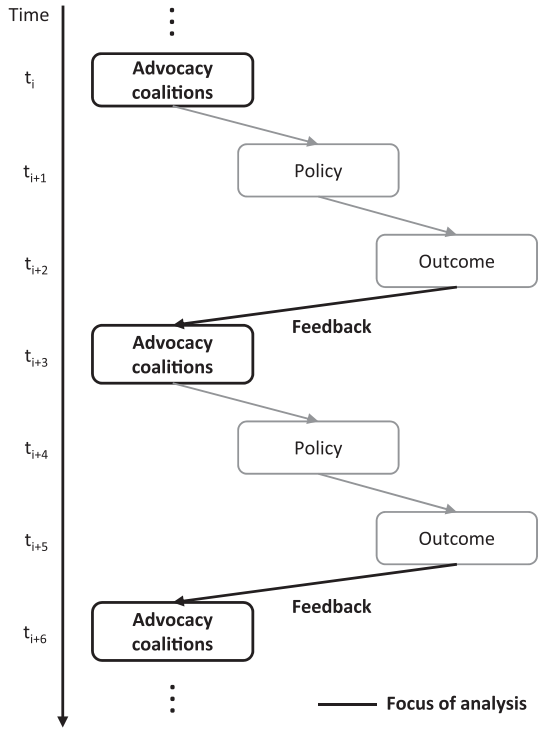

Figure 1. Conceptual Framework and Analytical Focus of the Paper.

1988). Yet, coalition change and the precise mechanisms between such change and exogenous factors are not well understood (Leifeld, 2013; Schlager, 1995). To further substantiate these mechanisms, we draw on policy feedback literature (Béland, 2010; Béland & Schlager, 2019; Jacobs & Weaver, 2015; Pierson, 1993). We argue that our understanding of the politics of policy change can be advanced by conceptualizing the long-term dynamics in policy subsystems as feedback mechanisms and their effects on advocacy coalitions. Such a feedback perspective requires a distinction between *truly exogenous factors* and *policy outcomes*. Importantly, policy outcomes should not be understood as "shock" but rather as an integral part of long-term feedback *loops* among policy, policy outcomes, and subsequent politics. Most current societal challenges, such as environmental degradation or economic crises, are not truly exogenous but are at least partly policy-induced challenges. We therefore propose a conceptual framework for understanding the politics of policy change as a result of policy outcomes and their feedback effects. Our framework differs from extant public policy research which largely analyzes the politics of policy change as a driver—rather than a result—of policy outcomes. The main point of the paper is to provide this novel and complementary perspective. Our guiding research question is: *How are politics affected by feedback from policy outcomes?*

Empirically, we focus on policy-induced technological change as a distinct form of policy outcomes (Schmidt & Sewerin, 2017) and its effects on advocacy coalition

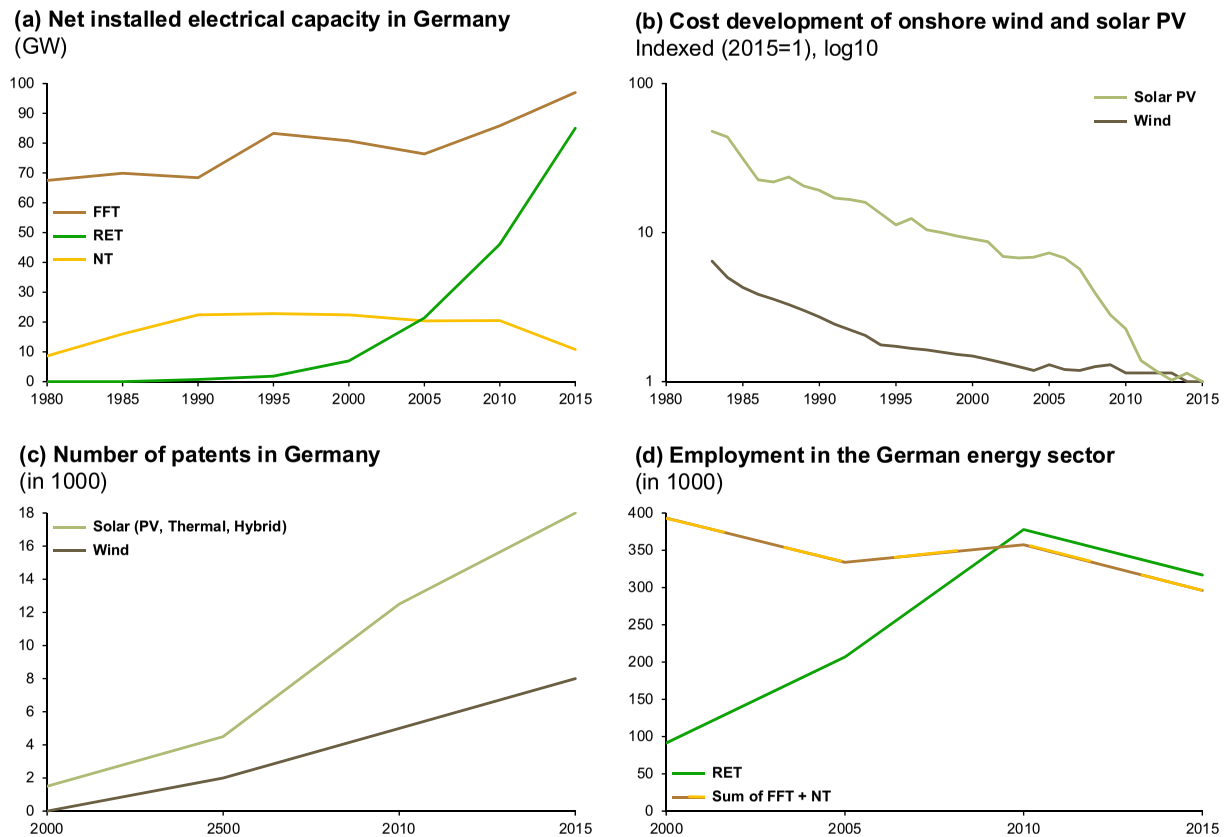

Figure 2. Technological Change in the German Energy Subsystem.
Notes: (a) Net installed electrical capacity in Germany. Based on data from IEA; RET including solar PV, wind on- and offshore, geothermal, and hydro; FFT including coal (hard coal and lignite), natural gas, and liquid fuel. (b) Wind indexed based on levelized cost of electricity; for 2010–2017 data has been taken from IRENA, while that for earlier years is based on data from BNEF and Lawrence Berkeley National Laboratory; solar PV index is based on the module cost, and data is taken from Fraunhofer ISE. (c) Number of patents in Germany; based on data from IRENA. d) Employment in the German energy sector. Based on O'Sullivan, Edler, and Lehr (2018), estimated from employment through investment in energy technologies and employment in energy generation, distribution, and transmission. [Colour figure can be viewed at wileyonlinelibrary.com]

change, here understood as the relative strength and structure of *technology-specific* advocacy coalitions. More specifically, we analyze advocacy coalition change in the German energy policy subsystem during the period 1983–2013. We proceed in two steps: First, we conduct a Discourse Network Analysis (DNA) to assess coalition change in the German energy subsystem (Leifeld, 2016). Second, we use theory-building process tracing to establish both the mechanisms and the effects that link policy-induced technological change to coalition change (Beach & Pedersen, 2013). With DNA, we show that the advocacy coalitions that support fossil fuel-based technologies (FFT) and nuclear technologies (NT) become less powerful in the subsystem, while the advocacy coalition for renewable energy technologies (RET) increases in terms of size and actor diversity. In more general terms, we find patterns of *coalition decline* and *growth*, which we explain with four actor movements: *disappearance*, *appearance*, *dissociation*, and *association*. Through process tracing, we identify four ideal-typical feedback mechanisms explaining these actor movements: *negative resource*, *positive resource*, *negative interpretive*, and *positive interpretive*. Then, we develop propositions how these feedback mechanisms and the resulting actor movements relate to four trajectories of policy change: *stability*, *contraction*, *expansion*, and *transformation*. Finally, we discuss the relevance and implications of our findings for the ACF, feedback, energy transition, and policy design literatures.

The remainder of the paper is structured in the following manner: Section 2 discusses the limitations of ACF research and how policy feedback literature might help address these limitations. Section 3 outlines the research case and method. Section 4 presents the results of our analysis. Section 5 presents the implications of our findings for policy theories. Section 6 discusses the relevance of our contributions for specific literature streams and concludes the paper.

2. Theory

2.1. Understanding Policy Change through Advocacy Coalition Change

Understanding how and why policy change comes about is a central issue in policy research. The ACF explains policy change as a function of changes in advocacy coalition structures within a policy subsystem (Fischer, 2014; Jenkins-Smith, Nohrstedt, Weible, & Sabatier, 2014; Sabatier, 1988). Such coalition change occurs because of individual actors' belief changes (Sabatier, 1988). Beliefs are structured into three hierarchical belief levels, and actors seek to translate these beliefs into policies through coordinated action within advocacy coalitions (Weible et al., 2011). Hence, at its core, the ACF postulates that it is necessary to understand the drivers of changes in actors' beliefs, hence coalition change, to explain policy change (see Figure 1). In the ACF framework, exogenous factors are identified as important drivers for belief change. As Sabatier (1988, p. 134) argued, "changes in relevant socioeconomic conditions (…) can dramatically alter the composition and the resources of various coalitions and, in turn, public policy within the subsystem." Despite the prominence of exogenous factors in the ACF, explicit hypotheses on linking such factors to coalition change have mostly remained unclear

(Kübler, 2001; Leifeld, 2013; Mintrom & Vergari, 1996; Nohrstedt, 2010; Schlager, 1995). This might be because the ACF focuses on defining and describing coalition constellations at a given point in time (Weible, Ingold, Nohrstedt, Henry, & Jenkins-Smith, 2019), rather than on explaining why coalitions change over time (John, 2003; Mintrom & Vergari, 1996). Of the few empirical studies that have explored coalitions over time, most have produced evidence of coalition stability, even in the context of significant external shocks (Matti & Sandström, 2011; Pierce, 2011; Pierce, Peterson, Jones, Garrard, & Vu, 2017; Weible et al., 2011; Zafonte & Sabatier, 2004).

To overcome this impasse, researchers have engaged with the exact *mechanisms* through which exogenous factors affect coalition change, and ultimately policy change (Leifeld, 2013; Nohrstedt, 2010; Weible et al., 2011; Weible & Heikkila, 2016). For example, Nohrstedt and Weible (2010) proposed hypotheses on the interaction between short-term exogenous factors and coalition change. Their discussion and other related contributions suggest three reasons why research efforts are stalling. First, the diversity of exogenous factors and the lack of clear definitions makes it difficult to establish generalizable mechanisms. As Nohrstedt and Weible (2010) argued, the conceptualization of exogenous factors is problematic because the label "crisis" encompasses a large variety of different phenomena, such as technological and macroeconomic change or public opinion. These factors might have different causal links to the policy subsystem, i.e., macroeconomic change might relate differently to advocacy coalitions than would public opinion. Second, the vocabulary used by researchers focuses on single events, and employs diverse concepts such as "crises," "external events," or "external shocks." These concepts mostly allude to the sudden character of exogenous factors, and emphasize the impact of single events and crises on policy change (compare Nohrstedt, 2008). The importance of long-term dynamics in these exogenous factors is underemphasized. Consequently, dynamic and long-term exogenous factors of coalition change remain understudied, despite their important role in shaping policy processes (Jones & Jenkins-Smith, 2009). For example, only a few studies investigated the role of socioeconomic development or technological change (see Markard, Suter, & Ingold, 2016). Third, in many policy subsystems, the dichotomy between endogenous and exogenous factors is artificial. The exogeneity of these factors is a matter of degree, ranging from *truly exogenous* events, such as large-scale earthquakes, to dynamics that are clearly *policy induced*, such as pensions or health insurance coverage, or the diffusion of RET. Indeed, exogenous factors, as conceptualized in the ACF and in other theories of policy stability and change (Baumgartner et al., 2009; Hall, 1993; Kingdon, 1995; Sabatier, 1988), are often outcomes of policy output within a subsystem.

More recently, Weible and Ingold (2018) engaged with these questions regarding the nature of exogenous factors and their temporality. They developed four categories of exogenous factors to explain coalition change or stasis: sudden events and shocks, enduring chronic threats, short-term spillovers between policy subsystems, and long-term sporadic changes in societal values. However, the authors neither discussed the *mechanisms* that link exogenous factors to coalition change, nor did they

conduct an empirical analysis. To substantiate such mechanisms, in the following, we draw on policy feedback literature for its established feedback mechanisms and focus on temporal dynamics.

2.2. Understanding Coalition Change through Policy Feedback

The central idea of policy feedback literature is to highlight temporality by arguing that policy change, over time, feeds back into the political process (Béland, 2010; Béland & Schlager, 2019; Jacobs & Weaver, 2015; Larsen, 2018; Pierson, 1993; Skocpol, 1995). While classical feedback literature has focused on the specific link between policy and subsequent politics, more recent research has expanded the focus to the feedback *loop* from policy to subsequent politics to subsequent policy (Jordan & Matt, 2014). Despite these important contributions, conceptual challenges remain because the individual elements of the feedback loop and their relation to one another are not clearly defined (Campbell, 2012). For instance, the role of *policy outcomes* and their relation to and distinction from policy output and politics has not been conceptualized sufficiently. Nevertheless, in contrast to the ACF and other general theories of policy change, policy feedback literature allows us to distinguish between *truly exogenous factors* and *policy outcomes*. We argue that most current societal challenges are not truly exogenous, rather, they are part of a feedback loop and hence contain endogenous components (Pierson, 1993; Schmidt & Sewerin, 2017). When applied to the ACF, such a distinction implies that, in most policy subsystems, coalition change is affected by policy outcomes rather than being influenced by truly exogenous factors (Nowlin, 2016).

To conceptualize policy outcomes, their relation to the other elements of the feedback loop needs to be defined (see Figure 1). First, we distinguish between feedback *mechanisms* and their *effects*. While the former describes a process and channel through which policy outcomes influence subsequent politics, the latter describes the impact of these mechanisms on subsequent politics. Second, one of the most central contributions of policy feedback literature is the distinction between *interpretive* and *resource* mechanisms (Patashnik & Zelizer, 2013; Pierson, 1993). Studies that investigated interpretive mechanisms viewed policies as sources of information and meaning, thereby changing cognitive evaluations (Pierson, 1993). Such interpretive feedback mechanisms are related to the ACF's concept of policy-oriented learning (Sabatier, 1988). Policy feedback can also affect politics through a resource mechanism. Policies provide means and incentives for actors through resource mechanisms, which influence their relative material power and create both winners and losers (Campbell, 2012; Patashnik, 2008). ACF scholarship discusses the effects of this resource mechanism as the result of an external shock or event (Nohrstedt, 2008). Third, the effects of these mechanisms on coalitions depend on the directionality of the interpretive and resource feedback mechanisms. Based on the distinction between *positive* and *negative* feedback mechanisms, Jacobs and Weaver (2015) described policy feedback as self-reinforcing when it stabilizes or expands policy support, and self-undermining when it undermines a policy's political viability over time.

2.3. Conceptualizing the Policy Feedback Loop with ACF and Feedback Literature

Bringing together both ACF and policy feedback literature enables us to conceptualize the complete policy feedback loop. Building on the ACF, we conceptualize politics as the relative strength and structure of advocacy coalitions that share common beliefs regarding desirable policy outcomes. By drawing on policy feedback literature with its dynamic conceptualization of the policy process, we explain coalition change with feedback mechanisms and their effects. Figure 1 depicts this feedback loop, which begins with politics, conceptualized as advocacy coalitions, at t_i. In keeping with the ACF, we assume that these coalition structures at t_i determine policy at t_{i+1}. In turn, these policies affect policy outcomes at t_{i+2}.[1] These policy outcomes feed back into subsequent politics through feedback mechanisms, and thereby lead to coalition change at t_{i+3}. In turn, such coalition change shapes subsequent policymaking at t_{i+4}, thereby triggering a new feedback loop, which alters policy outcomes at t_{i+5} and has feedback effects on advocacy coalitions at t_{i+6}.

Note that while our *conceptual* framework contains the complete feedback loop, the *analytical* focus of this paper is the feedback from outcomes on advocacy coalitions (colored in black in Figure 1).[2] Yet, by building on our inductive analysis, we develop theoretical propositions about the link between advocacy coalition change and policy change (see Section 5.2.).

3. Research Design

3.1. Case Selection

To explore the role of policy outcomes and their effects on politics, we analyze *technological change*—i.e., the invention, innovation, and large-scale diffusion of new technologies—for three reasons. First, technological change is a highly relevant phenomenon, as it is the primary driver of economic development (Schumpeter, 1942) and fundamentally affects social interaction (Borgmann, 1987) and the natural environment. Second, while occasionally perceived as fast, technological change is continuous and rather slow, since the process from invention to innovation to broad-scale diffusion of technologies can take significant time (Arthur, 2009; Rogers, 1962). Thus, technological change differs from exogenous "shocks" with faster impacts. Third, public policy and regulation have a strong influence on technological change (Lundvall, 1992; Rodrik, 2004; Rosenberg, 1982), e.g., through providing incentives to firms to perform research and development (Hall, 2002) or through altering relative market sizes and prices, which induce (re-)directed innovation (Acemoglu, 2002). Of course, the role of the state in inducing technological change differs by sector, but even in very "entrepreneurial" sectors, such as information and communication technology, the public sector was and is rather central (Mazzucato, 2015). Given this important role of the state, technological change is political (Winner, 1980) and, importantly, feeds back into the policy process (Edmondson, Kern, & Rogge, 2018; Schmidt & Sewerin, 2017). New technologies might result in new opportunities or challenges, which require new or adjusted policies (Hoppmann, Huenteler, & Girod, 2014).

Technological change in the *energy sector* is an extreme example of the three characteristics of technological change listed above. First, the energy sector is the largest contributor to anthropogenic greenhouse gas emissions, which are causing global climate change (IPCC, 2014). Hence, technological change in the energy sector is highly relevant, in that GHG-emitting technologies and practices have to be phased out and replaced by low- or non-emitting technologies (Geels, Sovacool, Schwanen, & Sorrell, 2017). Second, despite major shifts toward renewable energy technologies (RET) in the last decade (IEA, 2017), energy transitions require a long time (Grubler, Wilson, & Nemet, 2016), due to the complexity, scale, uncertainty, and inertia of and within the energy sector (Fouquet, 2016). Finally, innovation in the energy sector is largely policy-induced (Johnstone, Haščič, & Popp, 2010; Newell, Jaffe, & Stavins, 1999). Hence, the transition of the energy sector to low-carbon energy technologies strongly depends on public policy choices (del Río González, 2009; Nemet, 2009) and, consequently, the politics underlying these choices (Lockwood, Kuzemko, Mitchell, & Hoggett, 2017; Meadowcroft, 2009; Schmidt & Sewerin, 2017; Stirling, 2014).[3]

In our study, we focus on the energy transition in *Germany* as an "extreme case" (Seawright & Gerring, 2008) of policy-induced technological change in the energy sector. First, as one of the frontrunners of transitions to low-carbon energy systems, Germany is a very relevant case (Renn & Marshall, 2016). Due to early policy activity supporting RET, Germany enabled major advances in these technologies on a global level (Lauber & Jacobsson, 2016). Second, the German energy sector has undergone major changes in previous decades, to the benefit of RET and the detriment of fossil fuel-based technologies (FFT) and nuclear technology (NT). Figure 2 illustrates these long-term dynamics in the case of (i) installed capacity of FFT, NT, and RET; (ii) levelized cost of RET;[4] (iii) number of patents for solar PV and wind technologies; and (iv) employment in FFT, NT, and RET.

Third, extensive empirical evidence demonstrates that these developments in the German energy sector are mostly a result of policy intervention (Hoppmann et al., 2014; Lauber & Jacobsson, 2016; Peters, Schneider, Griesshaber, & Hoffmann, 2012; Polzin, Migendt, Täube, & von Flotow, 2015). For example, with regard to FFT, German policymakers launched a gradual hard coal mining phase out in the 1980s, while protecting the industry in this transition period through subsidies of up to €327 billion between 1983 and 2014 (Renn & Marshall, 2016). More recently, German policymakers started negotiations to phase out lignite mining and coal power plants (Leipprand & Flachsland, 2018). Further, NT was introduced in the 1970s with significant state subsidies, but phased-out by the German government first in 2002 and ultimately in 2011. With regard to RET, the German government began subsidizing solar panels with research and development programs in the early 1980s (Jacobsson & Lauber, 2006). In 2000, the feed-in law introduced fixed and subsidized feed-in tariffs for electricity from RET compared to the previous feed-in law from 1990, which were decoupled from electricity prices (Lauber & Jacobsson, 2016). In our empirical analysis, to address the politics underlying these policies, we focus on three periods within the German energy transition: the tenth (1983–87), fourteenth (1998–2002), and seventeenth (2009–13) legislative periods.

They represent crucial periods of the fundamental (re-)orientation of the German energy sector, during which competition between FFT, NT, and RET was particularly salient (Renn & Marshall, 2016).

3.2. Methods

To investigate whether and how policy-induced technological change affects coalition change, we apply a mixed methods approach, proceeding in two steps: (i) In order to identify coalition change, we apply discourse network analysis (DNA). (ii) To explain this coalition change, we complement the DNA with theory-building process tracing.

(1) DNA is a combination of content analysis and social network analysis (Leifeld, 2013, 2016). It fits well into the ACF conceptualization of coalitions and is commonly used to identify advocacy coalitions. Based on the coding of text, the method creates two-mode affiliation networks by linking actors (such as firms, NGOs, political parties) to concepts (see Figure 7 in the online appendix for a graphical overview; for a detailed description of the method, see Leifeld [2016]). In our case, concepts are attitudes and arguments in favor of energy technologies. With such an actor–technology network, we apply network tools in order to visualize the change in networks over time. To do so, we proceed in three steps. First, using DNA software (Leifeld, 2016), we produce unstandardized two-node actor–technology affiliation networks. Importantly, here, we focus on *support* affiliation networks, not additionally analyzing *rejection* affiliation networks[5] (as done by Metz, Leifeld, & Ingold, 2018). Next, using the software *visone* (Brandes & Wagner, 2004), we visualize these networks with the quick layout using stress minimization techniques. In order to facilitate visual analysis within and across networks, we color the actor nodes according to their technology-specific support. In the case of two or more supported technologies per actor, we color the node according to the most frequently supported technology, i.e., the highest tie weight between an actor and a technology. To provide a quality index for the partition of our networks into communities, we calculate modularity scores: Following Everett and Borgatti's (2013) dual-projection approach, we run a modularity analysis of the underlying one-mode actor congruence networks, using the Louvain algorithm[6] (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008).

(2) With process tracing, we seek to provide evidence that policy-induced technological change is a driver of coalition change and investigate the mechanisms underlying their relationship. As a distinct case study methodology, process tracing attempts to identify the intervening causal process between variables (Collier, 2011): it can be used "when we know an outcome (Y) but are unsure what caused it to happen (i.e., X is unknown)" (Beach & Pedersen, 2013). Deductively, building on existing theoretical work, theory-building process tracing investigates the empirical material in the case, using evidence as clues about the possible empirical manifestations of an underlying causal mechanism. To do this, process tracing focuses on events over time, taking snapshots of a series of specific moments, which in turn enables the analysis of change and sequence. Then, findings can be generalized in

order to build theory. Here, in line with Collier's "Hoop test" (Collier, 2011), the aim of process tracing is to affirm the relevance of policy-induced technological change as a necessary, yet not sufficient, factor of coalition change.

3.3. Data

For data collection, we followed the steps as described by Leifeld (2013). We draw on two data sources: newspaper articles for DNA and protocols from plenary debates in the German parliament for process tracing. First, we collected newspaper articles that enabled us to identify coalition change in the three periods. As source, we selected the Frankfurter Allgemeine Zeitung (FAZ) archive, since it is the only nationwide German quality newspaper with an electronic archive that dates back to the 1980s.[7] We restricted newspaper articles to general energy policy topics in both the economy and politics sections of the newspaper (see Table 4 in the online appendix for more details). With this filter method, we obtained a total of 3387 newspaper articles. Second, to link policy-induced technological change to coalition change, we complemented our dataset with protocols of the German parliament. Using the official archive of the German parliament, we filtered parliamentary processes according to the key word "nuclear energy." We selected this keyword because debates on NT are the only constant topic on the German energy policy agenda from 1983 to 2013, including debates on the (re-)orientation of the national energy sector. Out of this corpus, based on qualitative assessment of their relevance, we selected protocols of 30 parliamentary debates (see Table 2 in the online appendix). Next, we coded the newspaper articles and parliamentary protocols. We developed a codebook through an iterative process, based on existing literature and pre-analysis of newspaper articles (see Table 3.1 in the online appendix). One researcher encoded the articles, while another controlled the coding. This four-eye principle ensures the validity and reliability of the coding process (Eisenhardt, 1989). Apart from the control coding by a second researcher, we employed a full-text search based on regular expressions to find potentially missing statements (Leifeld, 2013). The coding of the newspaper articles yielded 3900 coded statements made by 288 actors. In our coding, similar to previous research (e.g., Heikkila, Berardo, Weible, & Yi, 2019), we do not capture all three ACF belief levels but focus on policy core beliefs in a given policy subsystem. Such a simplification is necessary to be able to meaningfully analyze coalitions over time and across cases (Heikkila et al., 2019; Jenkins-Smith et al., 2014). We operationalize these beliefs as (i) *attitudes*, e.g., preferences toward energy technologies and (ii) *arguments* supporting these attitudes. For our analysis, we aggregated supportive attitudes and arguments specific to three technology groups: FFT (hard coal and lignite), NT, and RET (solar PV, wind on- and offshore, biomass, geothermal, and hydro).[8] We excluded natural gas and oil from FFT as these technologies were not salient issues of conflict in the German energy subsystem. Note that due to space limits, here, we focus on *positive* statements on these technologies in order to measure technology-specific *support* coalitions (refer to Table 3.1 in the online appendix for the details of code aggregation).

4. Results

First, we present our findings on how coalitions in the German energy subsystem changed over the three periods. Second, we explain coalition change as the effect of policy-induced technological change.

4.1. Describing Advocacy Coalition Change in the German Energy Subsystem

Figure 3 illustrates the two-mode actor–technology networks of each period.[9] In light of our research question, four observations can be made. First, through network visualization, we identified three advocacy coalitions around FFT, NT, and RET in all three periods (see colored nodes). Hence, there are coalitions in the German energy subsystem that coalesce around specific energy technologies. Second, these coalitions are not perfectly isolated from each other. On the contrary, a few actors within each coalition share energy technology-related beliefs with other coalitions. This is particularly the case in the first and last networks.[10] Third, the three coalitions change considerably over time. In the first network, which represents the German energy subsystem from 1983 to 1987, most actors coalesce around FFT and/or NT, which constitute the predominant energy technologies in the subsystem. A substantive part of each of these FFT or NT actors supports both energy technologies. The RET coalition is fairly small in comparison, with only a few ties to other coalitions. In the second network (1998–2002), both FFT and NT coalitions are still important. However, the ties between the FFT and NT coalitions became weaker as compared to the first network. Simultaneously, the RET coalition grew in terms of number of actors, and exhibits considerably more ties to both FFT and NT coalitions than in the previous period. In the third network (2009–13), the RET coalition is the largest, both in terms of the number of actors and in terms of ties to other coalitions. At the same time, the FFT and NT coalitions became much smaller. In other words, the FFT and NT coalitions show a strong gradual *decline* over the three periods, whereas the RET coalition exhibits remarkable *growth*. Although not observed empirically, these two patterns have two theoretical extreme points, namely coalition *dissolution* and coalition *formation*. Fourth, the results of the network analysis suggest that coalition decline and growth are the results of four different actor movements.

A first identified movement is *actor disappearance,* which led to the decline of the FFT and NT coalitions. An example for actor disappearance is the nuclear branch of Siemens, Areva NP (see circled actor #8 in Figure 3).[11] In contrast to actor disappearance that resulted in the decline of the FFT and NT coalitions, the RET coalition was strengthened through *actor appearance*. For example, the establishment of firms such as the Naturstrom AG and its appearance in the energy subsystem led to growth of the RET coalition. Apart from actor disappearance, *actor dissociation* from a coalition can also lead to coalition decline. For example, from the first to the second periods, the federal Social Democratic Party (SPD, circled actor #15) dissociated itself from the NT coalition. Similarly, apart from actor appearance, coalitions also grow as a result of *actor association*. For example, in the second period, the federal Conservative

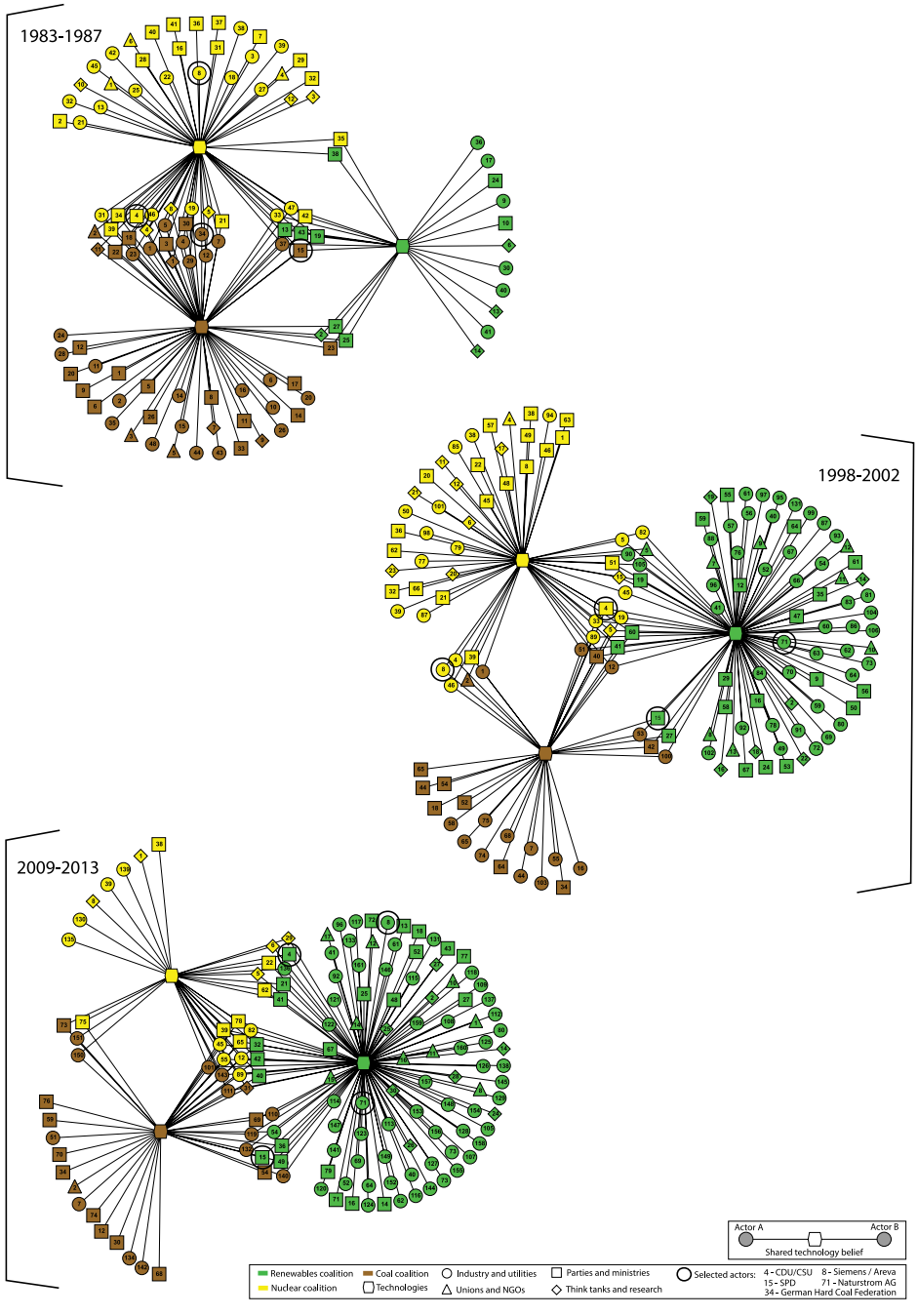

Figure 3. Change in Advocacy Coalitions in the German Energy Subsystem from 1983 to 2013.
Notes: The two-mode support affiliation networks represent the German energy subsystem in three periods: 1983–87, 1998–2002, and 2009–13. Nodes are actors that coalesce around the aggregates of positive statements on energy technologies (FFT, NT, RET). Refer to Table 6 in the online appendix for the list of actors. Networks are based on coding of 3387 newspaper articles, yielding 3900 coded statements of 288 actors. Note that the second-mode nodes are simplified aggregates of underlying, more complex, technology-support statements (see Section 3.2 for details on data and methods). Actor nodes are colored according to each node's most frequently supported energy technology. The graph layout is based on stress minimization. [Colour figure can be viewed at wileyonlinelibrary.com]

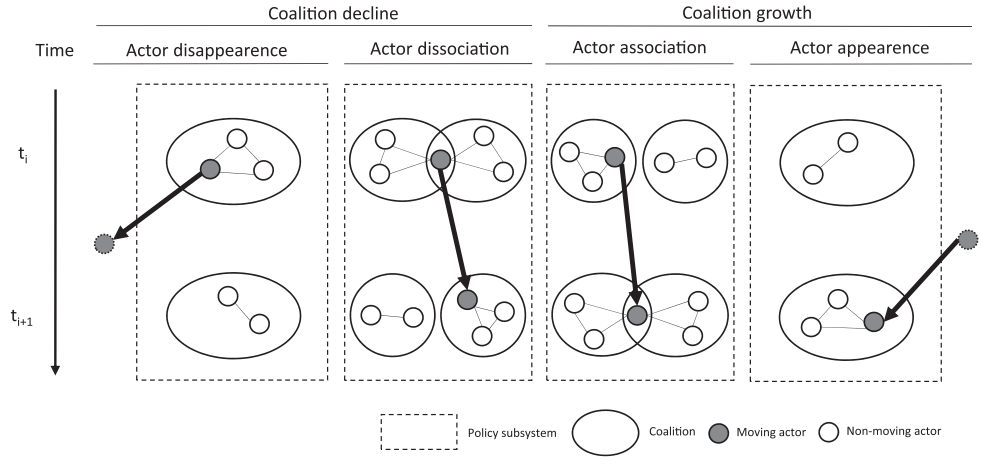

Figure 4. Stylized Actor Movements Underlying Coalition Change.

Party (CDU/CSU, circled actor #4) associated itself with the RET coalition (but did not yet dissociate itself from the FFT and NT coalitions).

In summary, the decline of the FFT and NT coalitions resulted from actor disappearance and actor dissociation. The growth of the RET coalition was the result of actor appearance and actor association from actors dissociating from the FFT and NT coalitions. Abstracting from these empirical findings, Figure 4 depicts a stylized visualization of the four actor movements from t_i to t_{i+1}. Note that dissociation from a coalition and association with another coalition can occur simultaneously, which would represent a *shift* between coalitions.

In sum, we argue that the combination of these four actor movements can explain coalition decline and growth, and hence explain the changing topography of the German energy subsystem.

4.2. Understanding Coalition Change through Policy Feedback

In the next step, we qualitatively assess whether and how policy-induced technological change was a driver of the actor movements observed above. In keeping with theory-building process tracing (see Section 3.2), we search for empirical manifestations of underlying causal feedback mechanisms (compare Section 2.2 for the theoretical discussion of these mechanisms) between policy-induced technological change and the four actor movements. More specifically, we focus on the following actors: an NT industry technology firm, a new RET firm, the federal Social Democratic Party and the federal Conservative Party.[12]

Actor disappearance can—among others—be observed in the German nuclear industry. In hindsight, the NT industry was at its peak at the beginning of the first analyzed period (no new power plant was built after 1982), and was later affected by the nuclear accident in Chernobyl in 1986. In the second analyzed period, after years of intense conflict around NT, the decision by the Red-Green government to phase out nuclear energy in 2002 triggered a steady decline of the nuclear industry, reinforced by

the second phase-out decision by the Conservative-Liberal government in 2011 (Renn & Marshall, 2016), i.e., during the third analyzed period. As a result of these major policy changes, the installed capacity of this technology decreased from 22.4 GW in 2000 to 10.8 GW in 2015 (see Figure 2a). In turn, this policy-induced technological change led to substantial actor disappearance from the NT coalition between the second and third periods. For example, Siemens, a German engineering company which had built all 17 of Germany's nuclear power plants, completely discontinued its nuclear reactor business in 2011 (Renn & Marshall, 2016). In other words, an important actor in the German energy subsystem disappeared, largely as a result of the policy-induced decline of its home market. At a higher level of abstraction, we reason that policy-induced technological change triggered actor disappearance through a *negative resource feedback mechanism*.

An example for actor appearance is the entry of new firms in the German energy subsystem (e.g., Naturstrom AG). As a result of early support policies between the first and second periods, new demand for RET emerged in the 1990s (Jacobsson & Lauber, 2006), thereby triggering the entrance of early movers into the RET market (Strunz, 2014). In addition, industry associations and research institutes were established, such as the German Wind Energy Federation or the Institute of Ecology. In the second period, the introduction of a more stringent feed-in tariff with technology-specific remuneration triggered an exponential growth of the RET sector (Hoppmann et al., 2014). As a result of this distributional policy, between 2000 and 2015, installed capacity of RET increased from 6.96 to 85.01 GW (cf. Figure 2a). As the RET market continued to grow, driven by sustained policy support, specialization, and positive externalities further increased actor diversity (Steffen, 2018). These new actors entered the energy policy subsystem, thereby resulting in a large RET coalition in the third period. To summarize, policy-induced technological change led to actor appearance through a *positive resource feedback mechanism*.

Further, changing beliefs on NT in the SPD illustrate how policy-induced technological changes leads to actor dissociation. In the first period, the SPD held mostly positive beliefs regarding NT (Reference [1] in Table 7 of the online appendix). However, already in the beginning of the 1980s, beliefs within the SPD began to shift. A major reason was that the policy-induced phase-in and subsequent diffusion of NT represented a strong competition for FFT, traditionally an important constituency for the SPD (References [4,6,8] in Table 7 of the online appendix). The SPD justified opposition to NT due to the lack of technological improvements in this technology, e.g., highlighting the failure of the nuclear fast breeder technology (Reference [47] in Table 7 of the online appendix). In the second period, the SPD justified its opposition to NT with decreasing economic competitiveness and the risks associated with NT (Reference [49] in Table 7 of the online appendix). In the third period, competition between NT and RET was an important reason for the SPD to oppose the plan of the Conservative Liberal party to slow down the nuclear phase-out (Reference [15] in Table 7 of the online appendix). Hence, SPD's increasing dissociation from NT is an example of the effect of *negative interpretive feedback mechanisms*. Notably, evidence suggests that the SPD's dissociation from NT *precedes* truly exogenous shocks, such as the Chernobyl and Fukushima nuclear accidents, which only reinforced already existing negative interpretive feedback (References [2,3] in Table 7 of the online appendix).

To illustrate the role of policy-induced technological change for actor association, we use the example of the CDU/CSU. In the first period, the CDU/CSU was neither supportive nor fundamentally opposed to RET. However, the CDU/CSU argued that RET could not be a large-scale solution to replace any other energy technology. In order to support this argument, the party referred, among others, to experiences with publicly funded research and development projects, such as the failed wind turbine project "Growian" (Reference [36] in Table 7 of the online appendix). The party's stance did not change much between the first and second periods. In the early 2000s, the CDU/CSU supported an energy concept based primarily on FFT and NT (Reference [29] in Table 7 of the online appendix), with only a small role attributed to RET (Reference [36] in Table 7 of the online appendix). The chances of RET to largely diffuse into the energy market, and for economic co-benefits to emerge, were estimated to be low (References [20,43] in Table 7 of the online appendix). However, in the third period, the CDU/CSU's opposition to RET had largely vanished. MPs of the party now referred to RET's rising share in the electricity mix as an argument in favor of this technology (Reference [45] in Table 7 of the online appendix). In contrast to earlier periods, the CDU/CSU highlighted co-benefits of increasing RET diffusion and underlined the strongly decreasing costs and increasing job creation (Reference [44] in Table 7 of the online appendix). Hence, CDU/CSU's association with the RET coalition is an example of the effect of *positive interpretive mechanisms*. Note that this association with RET *precedes* the Fukushima nuclear accident, which was a truly exogenous shock.

5. Implications for Theories of Policy Change

5.1. Explaining Advocacy Coalition Change with Policy Feedback

In Section 5.1, we empirically detect two patterns of coalition change—decline and growth—which we explain with four actor movements: *disappearance, appearance, dissociation,* and *association*. In Section 5.2, we identify four feedback mechanisms through which policy-induced technological change affects these actor movements, and hence coalition change: *negative resource, positive resource, negative interpretive,* and *positive interpretive*. We demonstrate that the actor movements that underlie coalition decline and growth are the effects of interpretive and resource feedback mechanisms. Combining the results of both analytical steps allows us to conceptualize the effects of policy feedback mechanisms on politics as patterns of coalition change and their underlying actor movements (see the 2 × 2 matrix in Figure 5). Developing an explanatory typology (Elman, 2005), we argue that combinations of the two dimensions of feedback mechanisms can explain the four actor movements and, consequently, coalition decline and growth.

We do not claim that patterns of coalition change and their underlying actor movements are *exclusively* triggered by these mechanisms; rather, we argue that resource and interpretive mechanisms are *more important* for specific actor movements, respectively: for actor disappearance and appearance, resource mechanisms are arguably more important because such changes require a (re)distribution of resources to nurture entrants and/or deprive incumbent actors. Interpretive mechanisms might be more relevant for actor dissociation and association because they

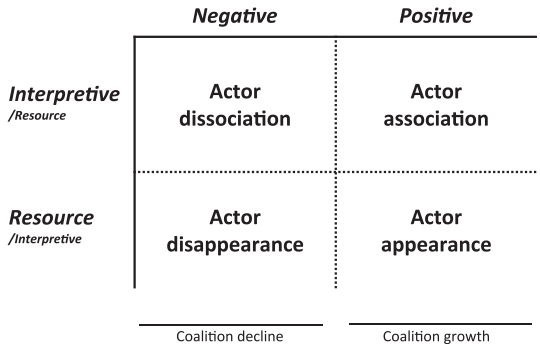

Figure 5. Feedback Mechanisms (Axes) and Their Effects on Actor Movements (Quadrants).

are concerned with belief changes of the incumbent actors based on the perception of real-world changes, such as policy-induced technological change. Hence, the relative prevalence of a specific type of actor movement depends on whether resource or interpretive mechanisms are more important in a given policy subsystem.

5.2. Explaining Policy Change with Coalition Change and Feedback Mechanisms

In the following, we additionally develop theoretical propositions on how the patterns of coalition change detected above explain policy change and thus how to conceptualize the complete feedback loop (as presented in Figure 1). We suggest combining ideal-typical trajectories of policy change with ideal-typical patterns of coalition change and their underlying actor movements. Figure 6 illustrates how four ideal-typical policy trajectories relate to the 2 × 2 matrix that is depicted in Figure 5. As proposed by Jacobs and Weaver (2010), we distinguish between *policy stability*, *expansion*, *contraction*, and *transformation*. We understand policy expansion and contraction to be instances of positive and negative minor policy change, respectively, and policy transformation to be major policy change.

We posit that these four policy trajectories can be explained with different combinations of feedback mechanisms and their effects on actor movements, and consequently coalition change. We make four propositions: First, policy stability results from coalition stability, which itself results from either the balance between or the absence of positive and negative feedback mechanisms. Second, expansion of policy$_i$ is caused by the growth of coalition$_i$ (actor appearance and/or association), which, in turn, is caused by positive resource and interpretive mechanisms. Third, contraction of policy$_j$ results from a decline of coalition$_j$ (actor disappearance and/or dissociation), which itself results from negative interpretive and resource feedback mechanisms. Fourth, policy transformation represents the most complex policy trajectory: it requires both decline of coalition$_k$ and growth of coalition$_l$. Here, negative resource and interpretive feedback mechanisms lead to the disappearance of incumbents and/or their dissociation from status-quo coalition$_k$. Simultaneously, positive resource and interpretive feedback mechanisms trigger the appearance of new actors and/or the association of incumbents with pro-change coalition$_l$. These

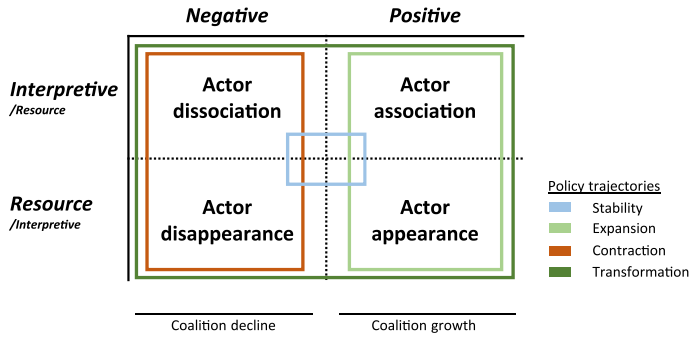

Figure 6. Feedback Mechanisms (Axes), Their Effects on Actor Movements (Quadrants) and Coalition Change, and the Link to Policy Trajectories (Colors). [Colour figure can be viewed at wileyonlinelibrary.com]

propositions advance the general understanding of policy change (Baumgartner et al., 2009; Cashore & Howlett, 2007; Hall, 1993; Kingdon, 1995; Sabatier, 1988) by conceptually integrating the politics of policy change and feedback mechanisms.

6. Discussion and Conclusion

In this paper, we explain advocacy coalition change as a result of feedback from policy outcomes. This perspective contributes to the discussion in theories of policy change regarding minor and major policy change and the role of endogenous and exogenous factors therein (Baumgartner et al., 2009; Cashore & Howlett, 2007; Hall, 1993; Kingdon, 1995; Sabatier, 1988). As an alternative to this strict dichotomy between endogenous and exogenous factors behind policy change, we argue that certain factors that underlie policy stability and change are neither truly exogenous nor truly endogenous. Instead, we consider such factors an integral part of long-term feedback loops which comprise both endogenous and exogenous elements. In such loops, policy outcomes at t_{i+2} are the result of policy at t_{i+1}, with subsequent effects on politics at t_{i+3} (see Figure 1). Here, in a different but complementary perspective to most extant literature, we focus on the link between such policy outcomes and subsequent politics. We argue that our understanding of the politics that underlie policy change can be advanced by conceptualizing the temporal dynamics in policy subsystems as a function of feedback mechanisms and their effects on politics. We build on the ACF to describe politics as the relative strength and structure of advocacy coalitions (Sabatier, 1988). In our empirical case study on policy-induced technological change in the German energy subsystem, we identify coalition decline and growth. More specifically, we identify four actor movements that underlie these coalition changes: *disappearance*, *appearance*, *dissociation*, and *association*. To explain these actor movements, and thus coalition change, we draw on policy feedback literature (Béland, 2010; Béland & Schlager, 2019; Jacobs & Weaver, 2015; Pierson, 1993) to establish the mechanisms by which policy outcomes at t_{i+2} affect advocacy coalitions at t_{i+3}. We found that policy outcomes, such as policy-induced technological change, can be drivers of coalition change through four feedback mechanisms: *negative resource*,

positive resource, negative interpretive, and *positive interpretive*. Hence, patterns of coalition change are the *effect*, rather than the *cause*, of policy outcomes, offering an alternative perspective to the ACF and other general policy theories. Based on these findings, we developed propositions on how coalition change and feedback mechanisms are linked to four policy trajectories: *stability, expansion, contraction,* and *transformation.*

In addition to these general contributions, our paper also speaks to four specific literature streams. First, the focus on coalition change rather than stability provides a complementary perspective to existing ACF research. Considering the long-term dynamics of feedback mechanisms, we inductively develop patterns of coalition change, decline, and growth, and their four underlying actor movements, which might enrich the ACF's description of coalition change. For example, our study confirms findings by Leifeld (2013), who found that coalition change is a nonlinear process in which the power balance between coalitions changes incrementally, including a period of polarization, before a coalition can reach relative hegemony in the subsystem. To this perspective, we add a focus on actor movements and the underlying mechanisms that lead to such coalition changes. Although not a result of our empirical analysis, one theoretical outcome of the proposed mechanisms could be polarization. Further, by explicitly discussing how policy outcomes are linked to actor movements, and thus coalition change, we speak to the ongoing discussion within the ACF community regarding the mechanisms that link exogenous factors to policy change (Nohrstedt & Weible, 2010; Weible & Jenkins-Smith, 2016). The use of policy feedback concepts within the ACF shows how the integration of different approaches can help the framework to gain more descriptive and explanatory leverage (Pierce et al., 2017). Second, we contribute to feedback literature by highlighting the role of actors and advocacy coalitions, i.e., agency, in long-term feedback loops. A classical policy feedback study might have underemphasized the political dynamics in its account of policy change. Further, we respond to calls for clearer definitions of feedback concepts (Campbell, 2012) by distinguishing between interpretive and resource feedback mechanisms and their effects. By explicitly considering the direction of policy feedback and empirically showing that the directionality of feedback has an effect on subsequent politics, we contribute to the ongoing discussion about self-undermining and self-reinforcing feedback (Jacobs & Weaver, 2015). As the existing feedback literature is mostly looking at mass politics (Béland & Schlager, 2019; Larsen, 2018), our focus on interest groups complements recent literature and helps fill this empirical gap (Goss, Barnes, & Rose 2019). With a focus on policy-induced technological change in the energy sector, we contribute to applying feedback concepts beyond well-trodden policy fields, such as social policy (Béland, 2010; Béland, Rocco, & Waddan, 2018). Third, through our empirical focus on the energy policy subsystem, we also contribute to the emerging literature on the importance of politics in energy transitions (Aklin & Urpelainen, 2013; Brisbois, 2019; Kern & Rogge, 2018; Normann, 2015; Rinscheid, Eberlein, Emmenegger, & Schneider, 2019; Rosenbloom, Meadowcroft, & Cashore, 2019; Schmidt, Schmid, & Sewerin, 2019; Stokes, 2016). Our paper directly responds to the research agendas set by Lockwood et al. (2017), Roberts et al. (2018), and Schmidt and Sewerin (2017), by applying two major policy theories to the subject of the politics of energy transitions

(Meadowcroft, 2009). Finally, understanding coalition change as the result of policy outcomes raises the question of whether and how such coalition change can be intentionally designed by forward-looking policymaking (Jordan & Matt, 2014; Levin, Cashore, Bernstein, & Auld, 2012; Meckling, Kelsey, Biber, & Zysman, 2015; Pahle et al., 2018), i.e., creating a virtuous feedback loop that ensures the political sustainability of policies (Patashnik, 2003). On a more general level, recent literature on policy design addressed similar questions of designing long-term policy trajectories (Capano & Woo, 2017; Howlett, Mukherjee, & Woo, 2015; Jacobs, 2008). Whether such a feedback loop can be generated also depends also on the institutional setups that structure policymaking (Skogstad, 2017).

While we believe that our contributions to these literature streams are conceptually relevant and empirically well-founded, we wish to highlight a few limitations of our study. First, our qualitative approach to explaining coalition change does not establish the relative explanatory power of policy-induced technological change as compared to other factors, such as single events, public opinion, or party politics. Acknowledging this weakness, we assert that the purpose of this paper is to build theory and make propositions that can be tested in subsequent research. Second, in our analysis, we do not capture *coordination* between coalition actors, which is another other key component of advocacy coalitions, along with beliefs (Sabatier, 1988). Although integrating both would have resulted in a more complete analysis, it is difficult to consistently measure coordination among actors in a longitudinal analysis. In keeping with the existing ACF research, we argue that shared beliefs correlate to a certain extent with coordinative behavior (Matti & Sandström, 2011), therefore, our analysis is a meaningful application of the ACF framework's main assumptions. Third, our focus on *aggregated* technology-related policy core beliefs—and on *support* coalitions—represents a simplification of the multi-layered belief structure of actors in the subsystem. However, we believe that such a level of granularity is necessary to be able to trace coalition change over time, which was the explicit focus of this paper.

To address these limitations and to build on the framework that was developed in this paper, future research should extend our analysis in at least three areas. First, to increase the validity of our conceptual propositions, research should expand the empirical scope to other countries and policy fields, while also considering other policy outcomes. We believe that our framework is applicable to policy subsystems in which induced change is not of technological nature, such as welfare, higher education, gender, or migration policy. For instance, in welfare policy, the introduction of private insurance schemes may lead to the creation of new firms, i.e., actor appearance, through a positive resource mechanism. At the same time, such policies may lead to the disappearance of public insurance companies through a negative resource mechanism. The introduction of private insurance schemes may also trigger changing policy positions of political parties, which may lead to either actor association or dissociation through a positive or negative interpretive mechanism. Comparative studies could provide more insights into the differences of feedback across such policy fields. Second, future research that would test our propositions with a more quantitative research design would allow to disentangle the relative

explanatory power of various factors of coalition change. Third, research could further substantiate patterns of coalition change, actor movements, and their drivers. For instance, an intriguing question is how a subsystem structure, i.e., coalition polarization or hegemony, is related to the feedback mechanisms and actor movements identified in this paper. Another important venue for future research could be to investigate the difficult distinction between interpretive and resource feedback mechanisms, as well as the conceptual difference between these feedback mechanisms and policy learning.

In this paper, we conceptualize the politics of policy change as an integral part of a complete feedback loop. By empirically showing that policy-induced technological change feeds back into advocacy coalition change, we highlight the dynamic interplay between policy outcomes and subsequent politics. Thus, we contribute to overcoming the strict dichotomy between endogenous and exogenous factors that drive minor and major policy change.

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Notes

We gratefully acknowledge the financial support provided by the Swiss National Science Foundation (Project number: PYAPP1_166905). We also would like to thank Chris Weible, Karin Ingold, Daniel Nohrstedt, and other participants of the ECPR Joint-Session 2018 in Nicosia; various participants at the ECPR General Conference 2018, at the ECPR Conference on Regulatory Governance 2018, the IST 2018; and the team of the Energy Politics Group at ETH Zurich for valuable input and feedback on this study. Thanks also to Joern Huenteler for inspirational discussions in the beginning of the project. The authors declare no competing financial interests.

1. By selecting policy-induced technological change in the energy sector as the outcome, we are able to build on existing literature on policy effectiveness, which has demonstrated the policy-induced character of this specific outcome (see Section 4.1. for details).
2. Note that our empirical analysis focuses on post-enactment feedback of policies while treating both the pre-enactment feedback as well as the link between policy and outcome as a black box.
3. In addition, policy-induced technological change and its relation to the policy-making process in the energy sector has been underemphasized in previous ACF and policy feedback studies (Kern & Rogge, 2018), and in existing public policy literature more generally (Cherp, Vinichenko, Jewell, Brutschin, & Sovacool, 2018; Meadowcroft, 2009; Schmidt & Sewerin, 2017). Proposing a new research agenda on energy transitions, Roberts et al. (2018) specifically address the need for more research on feedback and the factors of coalition change. Moreover, investigating energy policy with feedback literature is relevant, since most policy feedback studies have focused on social policy (Béland & Schlager, 2019), with only a few exceptions (Jordan & Matt, 2014; Lockwood, 2015).
4. Levelized costs of electricity generation strongly decreased for the two most important RET, solar photovoltaics (PV) and wind. Simultaneously, costs for Western nuclear power plants remained stable

or even increased in the 1980s and 1990s (Grubler, 2010), while costs for coal plants decreased only slightly (Rubin, Azevedo, Jaramillo, & Yeh, 2015).

5. However, we report the rejection affiliation networks in Figure 8 in the online appendix and the corresponding codebook containing the negative codes in Table 3.2 in the online appendix.
6. The algorithm optimizes modularity, a value between −0.5 and +1 (Brandes et al., 2008), which measures the density of links within communities compared to links between communities. If the value is larger than 0.4, the differences among communities are considered meaningful. In the calculation, we take into account the tie weight between nodes. Analyzing the modularity of the underlying one-mode *technology* networks is not necessary, as it consists of only three aggregated nodes for FFT, NT, and RET.
7. Although being vulnerable to bias in favor of certain actors (Kukkonen, Ylä-Anttila, & Broadbent, 2017), media analysis offers several advantages for longitudinal research: consistency in data collection, replicability, and data access (Heikkila et al., 2019). Further, the consistent use of one newspaper should limit bias variation over time.
8. To visualize the complexity of the underlying data, we report more disaggregated one-mode actor congruence support networks in Figure 9 in the online appendix.
9. Please refer to Table 6 in the online appendix for the list of actors (indicated with numbers in each node).
10. The underlying one-mode actor networks of the visualized two-mode networks differ in terms of their degree of modularity, with values 0.135 (1983–87), 0.244 (1998–2002), and 0.085 (2009–13). It is commonly assumed that coalitions can be meaningfully interpreted around 0.4 and higher (Kukkonen et al., 2018). In our view, the lower values do not pose a serious problem, since we are not claiming that these coalitions are isolated, and since we focus on coalition change rather than the perfect identification of coalitions at one point in time. For more network level statistics, see Table 5 in the online appendix.
11. An example of actor disappearance from the FFT coalition is the German Hard Coal Federation (see circled actor #34). Although still in existence as such, this federation no longer appears in our media analysis in the second and third periods, arguably because its relevance in the FFT coalition diminished.
12. The Social Democratic Party (SPD) and the Conservative Party (CDU/CSU) were both governing parties in the second as well as first and third periods, respectively. For the analysis, we use newspaper articles and a second data set based on parliamentary protocols (see Section 3.3). In the text, references to single newspaper articles or parliamentary debates are indicated in parentheses, referring to Table 7 (online appendix). Additional evidence on the stance of parties on energy technologies can be found in Table 8 (SPD) and Table 9 (CDU/CSU) in the online appendix.

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