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Research article

Analyzing transitions through the lens of discourse networks: Coal phase-out in Germany

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ABSTRACT

Discourse analysis is gaining attention in transition studies. This paper uses discourse network analysis (DNA) to study how discourse coalitions, and the storylines they mobilize, change over time. Drawing from archival data of two daily newspapers, we analyze the struggle over coal phase-out in Germany (2000–2020). We identify an anti-coal discourse coalition, which was stable and ideationally congruent over time. It used climate change as the dominant storyline to delegitimize coal. The phase-out policy decision in 2020 can be interpreted as the success of this coalition. The pro-coal coalition, in contrast, was more dispersed and less consistent in their arguments. Nonetheless, it was able to institutionalize some of their key storylines in the final policies. We argue that DNA is a powerful tool we can mobilize in sustainability transitions research for the study of politics and beyond.

1. Introduction

Sustainability transitions are highly contested. Different actors hold different views on the preferred direction and pace of the transition and we often see fierce struggles over public policies or technologies. Some actors, for example, work to legitimize a novel technology, while others express doubts and seek to delegitimize it (Binz et al., 2016; Markard et al., 2016b; Rosenbloom et al., 2016). Battles over legitimacy unfold not only for new technologies such as solar-PV but also for established technologies such as coal or nuclear energy (Geels and Verhees, 2011; Isoaho and Markard, 2020). Creation of legitimacy is a vital part of the innovation process, while undermining of legitimacy may eventually lead to decline.

One way to study struggles over legitimacy is through discourse analysis. In transition research, discourse analysis has attracted quite some attention recently (Isoaho and Karhunmaa, 2019). Scholars have studied discourse and competing storylines associated with regime destabilization (Lowes et al., 2020; Roberts, 2017; Rosenbloom, 2018; Turnheim and Geels, 2012), innovation (Rosenbloom et al., 2016) or the formation of landscape pressure (Falcone et al., 2018). While most studies focus on energy transition topics, there is also research on discursive struggles over genetically modified food (Jansma et al., 2020), wastewater systems (Ampe et al., 2020) or railroads (Roberts, 2017).

As these studies illustrate, discourse analysis resonates well with research in sustainability transitions. Researchers have argued that struggles over values (e.g. whether to prioritize low costs or clean air), ideas or expectations (e.g. on the future of energy supply)

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are a key element in transitions, next to conflicts over material and economic interests (Geels and Verhees, 2011; Turnheim and Geels, 2013). Discursive approaches highlight how problems and potential solutions are socially constructed as actors exchange views, frame their arguments and formulate narratives, e.g. with regard to the need for systemic change, or the role of specific technologies therein (Hajer, 1995, 2006).

An emerging but yet under-explored topic is about the formation and influence of *discourse coalitions*. Given that transitions are very complex, sector-wide processes, actors rarely work in isolation. Instead, they coordinate activities in various ways. They build networks, alliances or interest groups (Gray and Bernell, 2020; Hess, 2014; Kishna et al., 2017; Musiolik et al., 2012) and they also form discourse coalitions (Duygan et al., 2018; Lowes et al., 2020). Through discourse coalitions, actors join forces (e.g., as they share common storylines) in order to shape public discourse and eventually influence policy decisions.

While transition scholars are only beginning to study discourse coalitions in a more systematic way, researchers in policy studies have already gained more experiences in this regard (Leifeld, 2013; Rinscheid, 2015; Schmidt et al., 2019). In particular, they have developed and used *discourse network analysis* to empirically track the evolution of discourse coalitions over time and to identifiy conditions for their success in terms of dominating political debates and influencing policymaking (Leifeld and Haunss, 2012). These advances have created an opportunity to also explore the merits of this method for the field of transition studies.

Our paper presents findings from a network analysis of discourse coalitions. Our empirical case is the discourse over coal-fired power generation and coal phase-out in Germany. From a sustainability transitions perspective, coal phase-out is a central process in the ongoing energy transition and in larger efforts to mitigate climate change. We focus on the discourse in Germany, where the parliament adopted a coal phase-out policy in 2020. Based on newspaper articles, we track the public discourse about coal over roughly 20 years (from 2000 to mid-2020). We study how coalitions emerged and changed, what storylines they mobilized and which arguments were later taken up (institutionalized) in the policy decision. We discuss whether coalition characteristics such as stability, ideational congruence and actor base can be used as indicators for success.

We chose Germany because of a high level of controversy over coal (Leipprand and Flachsland, 2018). While the ongoing energy transition toward renewable energies has advanced substantially over the last two decades, and citizen support for the transition is very high (IASS, 2020; Rinscheid and Wüstenhagen, 2019), there was substantial political resistance to a coal phase-out, e.g. due to the high regional economic importance of domestic lignite mining and recent investments in new coal-fired power stations made by utility companies (Brauers et al., 2020; Leipprand and Flachsland, 2018).

Struggles over coal phase-out are currently a hot topic in transition studies. Coal-based power generation can be seen as "the single most important cause of carbon lock-in" (Garg and Steckel, 2017, p. 38). Scholars have studied resistance towards coal decline (Trencher et al., 2019), early regime destabilization (Turnheim and Geels, 2012), debates over decline (Leipprand and Flachsland, 2018), pathways for technology phase-out (Vögele et al., 2018) and processes that resulted in phase-out decisions (Gray and Bernell, 2020; Isoaho and Markard, 2020; Rosenbloom, 2018).

We make three contributions to the literature. First, by systematically examining the discourse on coal phase-out in Germany, we identify key storylines, two opposing coalitions and major changes in the discourse in a focal arena of legitimacy struggles for sustainability transitions. Second, we explore three indications about the conditions for coalitions to be successful in their quest to influence policymaking. Third, we strengthen the methodological repertoire in transition studies by applying a replicable and transparent methodology that fruitfully combines qualitative discourse analysis and quantitative actor network analysis.

Next, we embed our study in the literature, explain the key concepts and discuss how to capture the success of discourse coalitions. Section 3 introduces our research case and methods. Then we present the results. Section 5 offers a critial discussion and conclusions.

2. Theoretical background

This article is rooted in the literature on sustainability transitions. Sustainability transitions are long-term processes in which sociotechnical systems such as energy supply or transportation go through fundamental changes that are associated with sustainability targets (Markard et al., 2012). These targets are typically formulated by public policies, which is why struggles over policies play a crucial role (Meadowcroft, 2011; Roberts et al., 2018).

2.1. Politics of transitions and struggles over legitimacy

Transitions are highly contested, which is why research on the politics of transitions has received quite some attention in recent years (Avelino et al., 2016; Kern and Rogge, 2018; Markard and Rosenbloom, 2020; Roberts et al., 2018). Studies on politics often explore how actors and coalitions (seek to) influence public policies, technology standards, or societal values (Fuenfschilling and Truffer, 2016; Markard and Erlinghagen, 2017; Sarasini, 2013). Another typical battle is about technologies and their legitimacy (Binz et al., 2016; Jansma et al., 2020; Kishna et al., 2017). Technology legitimacy has been defined as the "commonly perceived alignment (or misalignment) of a focal technology with institutional structures in its context" (Markard et al., 2016b, p. 333).

Legitimacy plays a key role for innovation but also in processes of decline and policy debates about phase-out (Isoaho and Markard, 2020; Turnheim and Geels, 2012). Policy decisions to phase-out a technology do not come easily. Even though phase-out policies are becoming more widespread, they are not standard in the 'playbook' of public policy (Rosenbloom and Rinscheid, 2020). Importantly, phase-out policies require substantial support by a broad range of societal actors (Rosenbloom, 2018). To mobilize this kind of support, the focal technology first has to lose the legitimacy that typically surrounds established practices. Only if many actors find that the technology is no longer viable, phase-out policies have a chance to be passed and implemented.

Struggles over legitimacy can be intense. Actors with competing views and interests often mobilize a variety of strategies to

legitimize, or delegitimize, both novel and established technologies (Binz et al., 2016; Isoaho and Markard, 2020; Kishna et al., 2017; Markard et al., 2016b). A central arena in which struggles over legitimacy unfold is public discourse. Contrary to other arenas such as parliamentary debates (Leipprand et al., 2016), public discourse is widely accessible: many different actors can share their views on a specific technology and the broader policy issue. Exchanges in public discourse happen before, in parallel and after formal processes of policymaking. Both its accessibility and duration make public discourse an interesting venue to study long-term processes of (de-) legitimation. In other words: Studying battles over legitimacy in public discourse provides us with insights into the politics of transitions that go beyond (but also reflect) formal policymaking.

2.2. Discourse analytical approach

The role of language-use and the social construction of reality lies at the heart of discourse studies. We draw on Hajer's (1995; 2006) approach to discourse. With Hajer (2009; p. 59–60) we define discourse as "an ensemble of notions, ideas, concepts and categorizations through which meaning is allocated to social and physical phenomena, and which is produced and reproduced in an identifiable set of practices".

Hajer analyzes the use of language in political processes through an argumentative lens. Policy problems like the future of power supply become subject of argumentative struggles in which different societal actors try to make others see the policy issue according to their own views and realities. A central concept in Hajer's discourse analysis is the *storyline*: "a condensed statement summarizing complex narratives, used by people as 'short hand' in discussions" (Hajer, 2006; p. 69). Through storylines, actors select certain aspects of the discourse while excluding others, thereby reducing the complexity of policy issues. By activating a storyline, actors assume that the audience "will understand what they mean" (Hajer and Versteeg, 2005; p. 177). For example, the storyline "Coal is bad for the climate" condenses complex arguments on the release of CO_2 through the burning of coal, how CO_2 contributes to climate change and how climate change is bad for society and nature.

Hajer's approach has been taken up by a number of recent contributions to sustainability transitions (Ampe et al., 2020; Bosman et al., 2014; Falcone et al., 2018; Isoaho and Markard, 2020; Lowes et al., 2020; Roberts, 2017; Roberts and Geels, 2018; Rosenbloom et al., 2016; Rosenbloom, 2018). For instance, Lowes et al. (2020) show how incumbent, pro-gas actors engaged with policymakers and commissioned reports in order to establish a 'green gas' storyline aimed at protecting their own interests, notably by preventing the electrification of heating. Funcke and Ruppert-Winkel (2020) identify three discourse coalitions and their competing storylines capturing whether the future of the German electricity system will be centralized or decentralized. Roberts (2017) analyses how an accumulation of 'negative storylines' undermined the legitimacy of the US railway system between 1887 and 1945. These studies highlight critical roles of storylines in sustainability transitions, for example as cognitive anchors that help actors to construct shared realities, and as strategic tools to legitimize or delegitimize the use of certain technologies, thereby shaping future development paths of socio-technical systems.

However, they tend to pay less attention to the ways in which actor configurations emerge and change around these storylines. Such *discourse coalitions* have been defined as "the ensemble of (1) a set of storylines; (2) the actors who utter these storylines; and (3) the practises in which this discursive activity is based" (Hajer, 1995, p. 65). Below, we use the case of the German coal phase-out discourse to track discourse coalitions and their use of storylines at different points in time.

As groups of actors evoke the same storylines time and again, they leave a lasting impression and some actors may even dominate the discourse, at which point it will be very difficult, e.g., for policymakers, to ignore their voice (Hajer, 2006). The analysis of discourse coalitions therefore provides us with a tool to better understand the interplay of discourse and policymaking. So far, discourse coalitions are only beginning to receive attention in transition studies, which is why our study makes an important contribution here, not least with regard to the methodology we use.

2.3. When are discourse coalitions successful?

This section explores what it means for a discourse coalition to be successful and which characteristics of a coalition potentially drive its success. The section connects the theoretical background with the methods and results.

According to Hajer (2006), a discourse coalition becomes dominant if two conditions are fulfilled. First, an increasing number of strategically relevant actors use its set of storylines. Central actors such as the government or political parties "should be forced to accept the rhetorical power of a new discourse" (Hajer, 2006; p. 71). Second, "the new discourse should be reflected in the institutional practices of that political domain" (ibid.). This institutionalization can be viewed as the ultimate impact a discourse coalition can have. We therefore use it as a criterion for success: A discourse coalition is successful if its views, expressed by its major storyline(s), have become institutionalized in new policies, organizational practices or overarching policy principles.

In struggles over phase-out, the discourse is typically polarized: One coalition is in favor of phase-out, while the other stands against it. In such situations, the first layer of success is whether a policy change (here: phase-out) happens, or not. However, there is a second layer underneath, which is about the details of the policy decision, e.g. how fast the phase-out is implemented and whether and how actors are compensated. At this second level, storylines and arguments of the (seemingly) unsuccessful coalition may have been institutionalized as well, e.g. in order to strike a political compromise.

Next, we derive three characteristics of discourse coalitions that we expect to have an influence on whether a discourse coalition is successful or not: stability, ideational congruence, and actor base. While we do not aim at formally testing these expectations, we use them to guide and structure our analysis of the discursive struggle over legitimacy surrounding coal in Germany.

First, a successful discourse coalition is characterized by a high degree of stability over time. A discourse coalition that consistently

maintains a core set of storylines that are shared by its most central actors will be recognized more easily in political debates than a coalition whose actors and storylines change frequently (Leifeld and Haunss, 2012). Stability, however, should not be mistaken with rigidity: A stable coalition succeeds in the seamless integration of new arguments into the existing ideational repertoire, which may be relevant given changing socio-political or techno-economic circumstances (Benford and Snow, 2000). On the other hand, a discourse coalition that frequently shifts emphasis from one idea to another is less likely to be recognized as a relevant force in political debates and may find it difficult to ensure receptivity among policymakers.

Second, a successful discourse coalition is characterized by a high degree of ideational congruence. If the set of storylines that constitutes a discourse coalition is widely shared among actors, this will facilitate collective action and thus a coalition's mobilization power (Laumann and Marsden, 1979). Ultimately, as previous research on discourse coalitions indicates (Leifeld and Haunss, 2012; Tosun and Schaub, 2017), such ideational congruence of an actor coalition will influence its ability to shape policymaking. If, on the other hand, a discourse coalition is more fragmented with respect to specific ideas and storylines, this will weaken its ability to successfully shape policies – notwithstanding that even the actors in a more fragmented discourse coalition share a basic set of storylines.

Third, a successful discourse coalition includes politically powerful actors. Coalitions first need to build up a large constituency to gain visibility in a political debate (Leifeld and Haunss, 2012). However, size alone is insufficient to shape policy. Importantly, actors holding strategically relevant or authoritative positions need to join a discourse coalition to make it successful (Hajer, 2006). The phenomenon that strategically relevant actors, such as members of government, defect from one discourse coalition to join an opposing one has been observed in previous research and may be linked to major policy shifts (Rinscheid et al., 2020). While it is difficult to empirically unravel whether shifts in a coalition's actor base are due to changes in actors' ideas or simply reflect their strategic calculus, the discursive support of politically powerful actors is a necessary condition for the success of a discourse coalition.

3. Methods

3.1. Research case

Germany has historically relied heavily on coal for electricity generation (Renn and Marshall, 2016). Two different forms of coal are used in Germany: Lignite and 'regular' hard coal. Lignite is extracted domestically and some regions depend on it quite strongly, with 19,500 workers still employed in lignite mining in 2020 (Statistik der Kohlewirtschaft, 2021). Hard coal used to be sourced domestically as well, but mining steadily declined since the 1960s and Germany's last (hard) coal mine was closed in 2018.

In the 1990s, Germany initiated its 'Energiewende', a comprehensive transition of its electricity system away from fossil and nuclear resources and toward renewable energies. Initially, the energy transition focused mainly on the phase-out of nuclear energy, which has long been the focus of political debate due to a long history of severe socio-political conflicts over the associated risks (Leipprand et al., 2016; Rinscheid, 2015). Consequently, nuclear power declined from providing about 30% of power generation to 11% in 2020 (Fig. 2). The six remaining nuclear reactors will be shut down in 2021 and 2022 (three reactors each year).

In recent years, the energy transition debate has increasingly focused on the future of lignite and hard coal (Leipprand and Flachsland, 2018; Müller-Hansen et al., 2021). While they covered around 50% of Germany's power generation in the 2000s, both have started to decline recently, also due to a price increase in EU emission allowances.[1] At the same time, renewable energies (wind, solar, biomass) have grown massively. In 2020, they covered more than 40% of Germany's power generation (Fig. 2). But it remains unclear whether they can be ramped up fast enough to substitute both nuclear and coal, given that the transition has been markedly slowed down, in line with the interests of electricity incumbents (Lauber and Jacobsson, 2016), and resistance against new energy infrastructure, e.g. new wind turbines, is on the rise (Arifi and Winkel, 2020). Therefore, Germany faces a unique 'double phase-out' challenge as it seeks to replace two major sources of power generation at the same time.

3.2. Data sources and corpus creation

Our study builds on newspaper data. Compared to other data sources such as position papers or testimonies from legislative hearings, quality newspapers can be assumed to capture a broader array of actors participating in a political debate (Leifeld, 2013). In particular, newspapers have incentives to emphasize conflicts and struggles to attract attention (Bennett, 1996), and thus newspaper articles are likely to contain a more diverse set of actors and arguments than policy documents (Delshad and Raymond, 2013), including both incumbent and niche actors (Leipprand and Flachsland, 2018). Moreover, as newspapers are published regularly and frequently, they can generate a reliable base for systematic empirical investigations over time. Nevertheless, we acknowledge that newspaper data may not contain all actors that are part of a discourse, for instance with respect to specific local debates, and that some actor types (e.g., governmental actors) may be over- and others (e.g., niche actors) underrepresented. As we exclusively relied on printed articles, our analysis does not capture news that were only published online.

We selected the national daily editions of Süddeutsche Zeitung (SZ) and Die Welt as data sources. Both newspapers were selected according to the "quality press" criterion (Barranco and Wisler, 1999); i.e., they represent general news-oriented papers of high reputation. Both newspapers report regularly about German energy policy and were accessible through LexisNexis and the Bavarian

[1] Note that due to the Covid-19 pandemic, 2020 was not a 'regular' year and overall power generation was lower than in most years before. Only 2000-2002 saw lower numbers.

Table 1
Main storylines.

Delegitimizing storylines	Example	Legitimizing storylines	Example
D1 Climate *Coal is bad for the climate*	"We do not reach the climate protection targets by just expanding renewables. … We also have to take coal power plants gradually off the grids" [1]	***L1 Limited impact*** *Coal phase-out in Germany has little impact at a global scale*	"It's a fact that Lusatia or Garzweiler are not decisive for the global climate, but China, India and the US are" [2]
D2 CCS is no solution *Carbon capture and storage (CCS) technology is expensive, risky and delays a phase-out that is inevitable*	"The capturing of carbon dioxide [through CCS] consumes a lot of additional energy; also, its underground storage bears risks" [3]	***L2 CCS is a solution***	"Germany is dependent on coal-fired power. The challenge is to make coal power plants environmentally friendly. This is the goal of CCS technology" [4]
D3 Coal is expensive	"Not only nuclear, but also coal has been subsidised by the taxpayer for decades. The costs are significantly higher than what we are currently paying for the *Energiewende* and for renewables" [5]	***L3 Coal is cheap***	"As a supplier of particularly cheap 'base load power', lignite power plants are indispensable for Germany in the long run" [6]
D4 Coal is not needed *Coal can be replaced without jeopardizing the security of energy supply*	"A reduction of coal-fired power would be sensible in the light of a politically motivated *Energiewende* and easily possible due to excess capacities in the power market" [7]	***L4 Coal is reliable*** *Coal is needed to keep the lights on*	"Renewables are not by any means in the position to supply Germany, a center for industry, with reliable and cheap energy" [8]
D5 Economic modernization *Structural change is inevitable and there are new jobs in sustainable industries*	"Political foresight can transform problems into chances. … Good [regional] policy promotes investments in the affected regions and creates opportunities for citizens and companies in industries of the future" [9]	***L5 Unemployment*** *Coal decline leads to unemployment and structural disruptions*	"Lignite stemming from these coalfields is directly and indirectly connected to 60,000 jobs and around four billion euro of value creation. … This is not replaceable that easily" [10]

State Library's online archive. The two newspapers were also chosen for their different ideological stances to generate an ideologically balanced data set. While SZ rather represents social liberal values (Hachmeister, 2012) and has a relatively favorable stance on the German energy transition, Die Welt represents conservative, market-liberal values (Pointner, 2010) and a more critical stance on the energy transition in general.

The newspaper articles were accessed through the SZ archive and LexisNexis database. To identify relevant articles within the databases, we developed a search string based on several rounds of test searches with different keywords and keyword combinations. We considered only articles referring to the role of coal in the German energy system in at least *one sentence* as relevant. The final search string[2] was then used to search for articles that appeared between January 2000[3] and July 2020. After removing false positives from the sample, 610 newspaper articles make up our final dataset (329 *SZ* and 281 *Die Welt* articles).

3.3. Discourse network analysis: Coding and analysis

The coding and analysis of our data relies on discourse network analysis (DNA). Developed by public policy scholars to systematically trace policy debates (Leifeld, 2017), we used discourse network analysis as it allows to investigate discursive struggles in a structured way and over time. The method has been applied to a broad range of policy issues, including software patents (Leifeld and Haunss, 2012), pension policy (Leifeld, 2013), nuclear phase-out (Rinscheid, 2015), climate policy (Fisher et al., 2013; Kukkonen et al., 2018; Schmidt et al., 2019), energy transitions (Brugger and Henry, 2021; Rennkamp et al., 2017; Černý and Ocelík, 2020) or genetically modified organisms (Tosun and Schaub, 2017). DNA is a combination of qualitative content analysis and actor network analysis. It is a particularly well-suited method for applications of Hajer's approach because, like the latter, it relies on a conceptualization of discourse as being constituted through both a substantive layer (e.g., storylines) and a relational layer, which entails the discursive interaction of actors (see also Leifeld, 2017; Schmidt and Radaelli, 2004, p. 184). DNA allows to investigate discursive struggles by simultaneously tracing the presence of storylines over time and various properties of actor networks that coalesce around these storylines.

Applying DNA requires setting up a coding scheme and carefully coding the corpus of documents selected. To compile the coding scheme, we had to identify different storylines. To do so, we first created a subset of articles containing every third newspaper article. One researcher explored this set of articles and inductively distilled key arguments used in the discourse on coal. These preliminary storylines were then discussed among the researchers and compared with earlier studies on the discourse around coal decline (Isoaho and Markard, 2020; Leipprand and Flachsland, 2018; Rosenbloom, 2018). After several rounds of discussion, the final storylines were consolidated (Table 1). In line with our theoretical argument, storylines are employed either to *(re-)legitimize* (L) or *delegitimize* (D) the

[2] Original search string in German: *((Kohleenergie* OR Kohlestrom* OR Kohleverstromung*) AND (*ausstieg* OR *abschalt* OR Energiewende* OR Dekarb* OR Kohlendioxid*)) OR Kohleausstieg**; own translation into English: *((coal AND (energy OR power OR electricity)) AND (phase-out OR shutdown OR energy transition OR decarbonization OR carbon dioxide));* the asterisk * allowed to search for variations of words.

[3] The start date was chosen because since around 2000, energy transition and climate change started to appear on the policy agenda (Müller-Hansen et al., 2021).

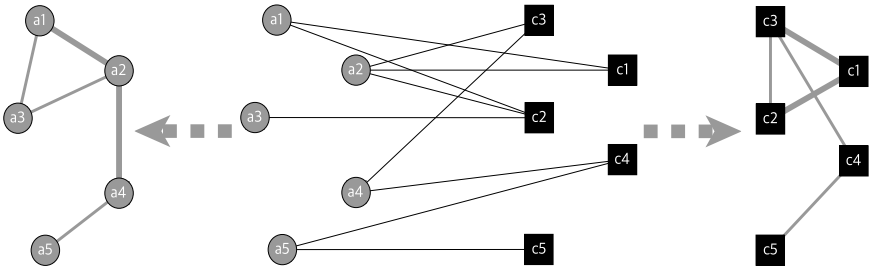


Fig. 1. Basic model of a discourse network. Based on Rinscheid (2020). Circles symbolize actors (a) and boxes symbolize storylines (c). The right network represents an affiliation network, and the left network illustrates the corresponding actor congruence network.

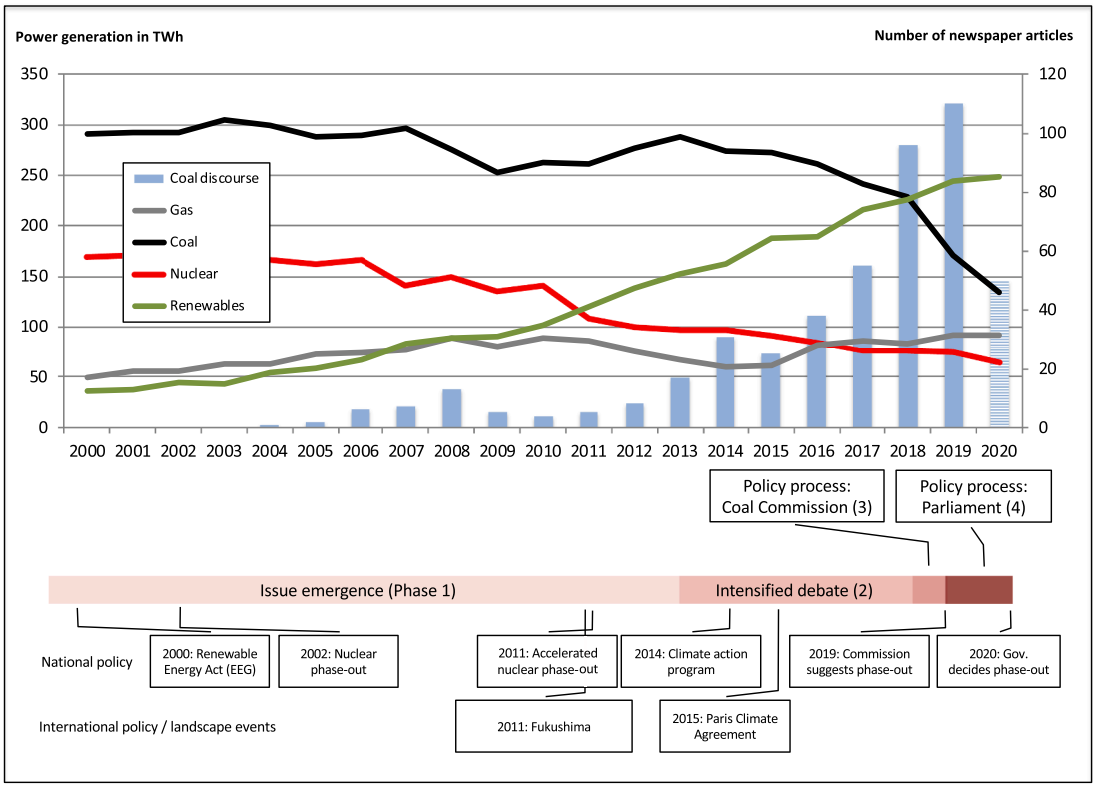


Fig. 2. Power generation, media attention, major policy events and phases of development. The bar for 2020 is shaded because it only covers articles until end of July 2020.

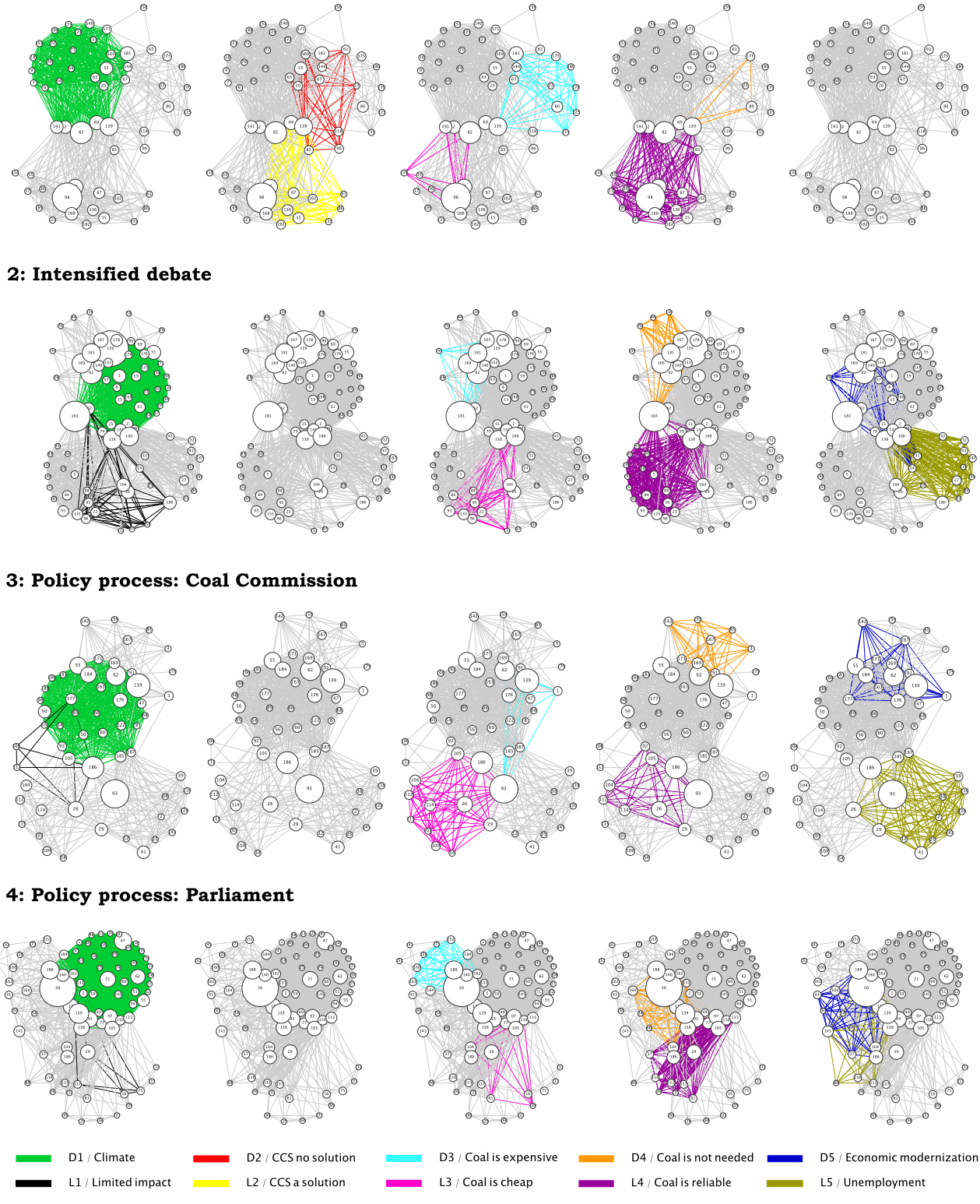
use of coal.

With the final coding scheme, we systematically coded the entire set of articles. The unit of analysis in DNA is the statement. Using the software NVivo, we manually coded all statements referring to coal or coal policy made by politically relevant actors. In particular, we coded the name of the actor who made the statement (considering individual and collective actors) and the storyline conveyed by the statement. To give an example, if a newspaper article reported on the Green politician Annalena Baerbock arguing that coal is devastating for the climate, we set an actor code for Bündnis 90/Die Grünen and a storyline code for D1 Climate.

We coded each storyline at maximum once per actor per article to ensure single actors or storylines not to be overweighed. Actors were grouped into distinct categories including federal government and state governments, political parties, energy companies, labor unions, science & thinktanks, and further actor types (see Appendix B: Actor codes).

Based on the resulting dataset, a so-called affiliation network can be generated to depict the relations between actors and storylines. The right part of Fig. 1 represents such an affiliation network in which the presence of a line (e.g., the link connecting the nodes representing actor a1 and storyline c2) indicates that a certain actor (a1) used the storyline symbolized by the adjacent node (c2) during the period of observation.

As affiliation networks are not very useful for the analysis of discourse coalitions, we transformed the data into one-mode projections that capture the relations among actors. The left part of Fig. 1 illustrates such a one-mode projection based on the underlying



(caption on next page)

Fig. 3. Actor congruence networks with paired storylines for each of the phases. Nodes (representing actors) are connected (via edges) if they share at least one storyline during the respective phase. The first column highlights edges linking actors who use either D1 or L1; the second column highlights edges representing D2 and L2, and so on. Node size is proportional to the number of statements made by an actor in the respective phase. Graph layout is based on a stress minimization (MDS) of graph-theoretic distances (Brandes and Pich, 2008). Graphs were generated with the open-source software visone.

affiliation network. In this actor congruence network, actor nodes are linked if the respective actors both use at least one common storyline (e.g., a1 and a2 are linked as both mention c1 and c2). The more densely connected two nodes are (depicted by line width), the more storylines they have in common. Our analysis makes use of these actor congruence networks to identify discourse coalitions and track their stability and reconfiguration over time.

4. Results

We show and compare our results across four phases of development, which are introduced next. Then we present the evolution of the entire discourse network over time. This is followed by the analysis of the three success characteristics of discourse coalitions introduced in Section 2.3. In a final step, we trace which storylines were institutionalized in the phase-out policy to explore the extent to which the two coalitions were successful.

4.1. Four phases of development

Inspired by Penna and Geels (2012), we distinguish different phases of destabilization and decline: (1) *issue emergence* – a time in which the issue is formulated and emerges in public debates, (2) *intensified political debate* – a phase in which policy actors become engaged, and (3) *political decision making* – a period that starts when the issue enters the formal policy process and ends with the policy decision. In our case, the third period consists of two distinct sub-phases, a commission phase and a parliamentary phase. This leads us to distinguish four different phases altogether (see Fig. 2).

Issue emergence (Phase 1): Throughout the first phase, when the issue of coal phase-out appears on the media agendas but attention for coal phase-out is still relatively low. The two main topics are that coal contributes to climate change and arguments around carbon capture and storage technology (CCS), which is presented as a solution to the carbon emissions of coal. More broadly, however, German energy policy debates are dominated by an intense societal discussion over the future of nuclear power. After the Fukushima accident, the German government resolves the nuclear issue in 2011 with a decision to accelerate the phase-out of nuclear. This creates room for new topics.

Intensified political debate (Phase 2): In May 2013, the German Green Party formulates the target to phase out coal in their program for the upcoming election. With this, coal phase-out enters the political arena, which is why we use this event to define the beginning of the second phase. In the second phase, the number of articles increases swiftly. A national climate action program and the Paris Agreement direct much attention to climate change and the contribution coal makes to it.

Policy process – Coal Commission (Phase 3): The third phase begins in April 2018, when the Christian Union parties (CDU and CSU) and the Social Democrats (SPD) sign an agreement to form a new government coalition. This agreement refers to coal as a "bridging technology": a first sign that the issue of coal use has reached the core of policymaking. Soon after, the government mandates a multi-stakeholder commission (official name: "Commission on Growth, Structural Change and Employment") to develop suggestions regarding the future of coal. In the third phase, media attention is very high. In January 2019, the 'Coal Commission' suggests a coal phase-out until 2038 (or possibly 2035). This is when attention peaks. It also marks the end of phase 3.

Policy process – Parliament (Phase 4): In the final phase, the discourse shifts from *whether* to phase out coal to *how and when*. The government negotiates with the affected regions and energy industry representatives over the details of the phase-out. Media attention remains high. In July 2020, both chambers of the German parliament pass the law that regulates the phase-out of coal until 2038. This decision marks the end of phase 4. While the law was endorsed by a variety of actors, many have also criticized it as not ambitious enough (Section 4.4).

4.2. Evolution of the discourse network over time

Now we take a closer look at the storylines and the discourse network. Fig. 3 shows how frequently different storylines are used in each of the four phases and how the structure of the entire network changes. To reduce graphical complexity, we have disaggregated each of the four time slices into five graphs, which differ only with respect to the highlighted storylines. We combined each delegitimizing storyline with its legitimizing counterpart, so that each graph highlights a pair of the {D1/L1 ⋯ D5/L5} storylines.

Two discourse coalitions can be distinguished in all four phases: Those actors that seek to delegitimize coal ('D coalition') are linked via D storylines and those that seek to (re-)legitimize coal ('L coalition') are connected via L storylines. In each of the four phases, a few actors use both D and L storylines, thereby linking the discourse coalitions.

We find that D1 ("Coal is bad for the climate"; green edges) is mobilized early on and consistently throughout all four phases by a relatively high number of actors. As Regine Günther from WWF puts it:

Fig. 4. The actor congruence networks of both coalitions subdivided into 4 time slices. Nodes (representing actors) are connected (via edges) if they share at least one storyline during the respective phase. Node size corresponds to the number of statements made by an actor. Members of the L coalition are depicted by diamonds.

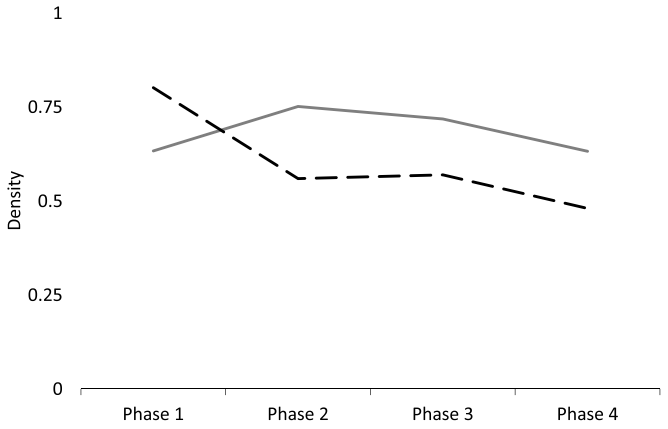


Fig. 5. Network density of the two coalitions of Fig. 4 over time. The black dashed line indicates the L coalition (= pro coal), and the gray line the D coalition (= pro phase-out).

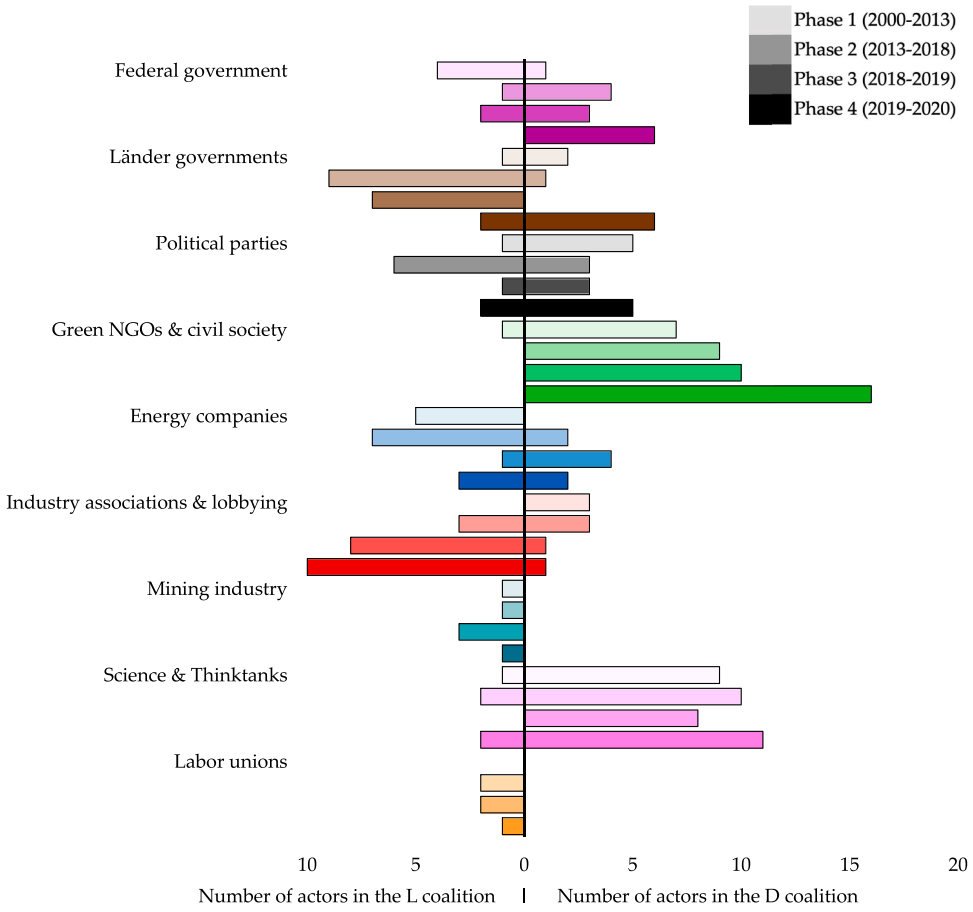


Fig. 6. The presence of actor types within discourse coalitions. The y-axis indicates number of actors present in a discourse coalition. The numbers to the left refer to actors in the L coalition, while the numbers to the right refer to actors in the D coalition. To simplify the visualization, the following actor types with low numbers of statements were excluded: Politics local level; Consultancy companies; Other companies; Administrative bodies; International organizations.

> "The power sector plays a key role [in the climate crisis] as more than 40 percent of German carbon dioxide originates from it. Around two thirds of German electricity stem from lignite and hard coal power plants, a type of power production that is extremely harmful to the climate" [11].

Of all storylines, D1 it is the most dominant and most consistent. Also, it is hardly contested. Its counterpart (L1; black edges) gains some prominence in phase 2 but it is only occasionally mentioned in the later phases.

With respect to the use of CCS as a technology to retain CO_2 emissions from coal combustion, our analysis reveals that the related storylines are only used during the first phase. The number of actors portraying CCS as a solution (L2; yellow edges) is similar to the number of actors rejecting it (D2; red edges). According to Claudia Kemfert from the German Institute for Economic Research:

> "CCS technology is questionable from the perspective of climate protection, as it undermines the aim of avoiding carbon dioxide. (…) (T)he deployment of CCS leads to additional costs and decreased efficiency [of power generation]" [12].

After 2013, there are no further arguments around CCS because the technology did not reach the pilot plant stage.

The costs of electricity and the argument that coal is cheap (L3, third column; pink edges) play some role throughout the entire discourse. L3 becomes quite prominent during the work of the Coal Commission (Phase 3) but loses importance thereafter when pro-coal actors focus on delaying the phase-out. D3 ("Coal is expensive"), on the other hand, is used intensely during the first and last phase. A think tank argues:

> "Unlike for renewables, we are going to pay for the follow-up costs of coal and nuclear power even years after their phase-outs" [13].

Throughout all four phases, many actors make the argument that "Coal is reliable" (L4) and an indispensible source of energy supply. Tuomu Hatakka from Vattenfall Europe argues:

> "I am wishing lots of fun and good luck to whoever believes a secure [power] supply may be uphold with renewable energies and some gas power plants. … [Such trials] are putting Germany's role as an industrial center at risk" [6].

The L4 storyline is particularly prominent during the phases of issue emergence and intensified political debate. Its counterpart, "Coal is not needed for a secure energy supply" (D4) is used by a slightly increasing number of actors during the four phases.

Especially during phase 2 and 3, actors advance the L5 storyline "Coal decline leads to job losses and structural disruptions" to legitimize the further use of coal. According to Michael Vassiliadis from the union IG BCE:

> "… in the mining regions, lignite is directly and indirectly connected to 60,000 jobs and around four billion Euro of value-creation" [15].

From phase 2 onwards, the contrasting storyline D5 "Structural change and transformation is necessary" is used by pro-phase-out actors. Kerstin Andreae from the Green party claims that:

> "[*i*]t is important to guide the structural change wisely for the locals and the regions that are losing a major economic sector. But there are economic sectors that need to transform" [14].

In summary, Fig. 3 helps to illustrate three important points.[4] First, the climate argument appears early on in the coal discourse and remains dominant throughout. Therefore, it can be viewed as the glue holding together the discourse coalition in favor of coal phase-out. Second, the pro-coal coalition appears to rely less on a specific storyline. Their most prominent argument is about reliability and security of supply (L4). This is complemented by storylines about structural disruption (L5), especially in phases 2 and 3. Third, and relatedly, Fig. 3 indicates that the pro-coal discourse coalition is more fragmented than the coalition calling for a phase-out. One reason for this fragmentation is that L4 and L5 are mobilized by different groups of actors.

4.3. Stability, ideational congruence and actor base of discourse coalitions

As indicated in Section 2.3, we expect that a successful discourse coalition is stable, ideationally congruent and attracts politically powerful actors. We look at these indicators one by one.

Fig. 4 entails separate actor networks of both discourse coalitions. These graphs are similar to those shown in Fig. 3, but actors who use both D and L storylines were allocated to one of the coalitions based on their specific tie profile, thereby removing bridges between the coalitions.[5] The D coalition appears to be very stable over time: it displays a core-periphery structure throughout the four phases, consisting of a densely interwoven core and a periphery that grows slightly over time. While the core coalesces around the D1 storyline and shows a high degree of stability with respect to the actors, the periphery includes actors using other coal-delegitimizing storylines. The pro-coal coalition, in contrast, is considerably less stable. While it also consists of a (less interconnected) main component in phase 1, it decomposes into two main components in phase 2 and remains scattered thereafter.

Our second expectation was that a successful discourse coalition is characterized by a high degree of ideational congruence, i.e. that many actors share the same storylines. Ideational congruence can be measured with network density, which captures the ratio of realized links to the maximum possible number of links in a network. Higher network density corresponds to higher congruence of actors with respect to the use of storylines. The highest possible density value in a network is 1 – in our case, this would correspond to a situation in which all actors in a coalition make use of all legitimizing, or delegitimizing, storylines. Fig. 5 shows that the ideational congruence of the L coalition is relatively high (0.80) during the issue emergence phase, but it decreases to levels between 0.48 and 0.57 in the following periods (black line). Conversely, the D coalition increases its density in phase 2 and only drops slightly thereafter,

[4] For more information on the actors and which coalitions they are part of, see Fig. A2 in the appendix.

[5] If actors use more D storylines than L storylines in a given time slice, they are allocated to the D coalition, and vice versa (see Leifeld and Haunss, 2012, p. 396).

remaining more congruent than the pro-coal coalition. This finding corroborates our expectation about the higher congruence of the D coalition as suggested in Fig. 3.

Third, we expected that a successful discourse coalition broadens its actor base so as to include more and more politically powerful actors over time. Fig. 6 shows for different groups of actors which type of storylines (L or D) they use and how this changes over time. This helps us to track how actor groups move from one discourse coalition to the other. Next, we look at the stable positions, then at the changes.

There are a few very stable positions: green NGOs & civil society actors (green) and science & thinktanks (pink) consistently mobilize pro-phase-out arguments throughout all phases. Taken together, these are also the most prominent voices in the D coalition. Among the political parties (gray), which are split over the phase-out question, the Green Party is the most active in the D coalition and consistently mobilizes pro phase-out storylines (see Table A3 in the appendix for a list of the 20 most active actors). The L coalition has two consistent voices as well, the mining industry (cyan) and the labor unions (orange). Among the energy companies (blue), RWE is also very persistent in their arguments pro coal.

Many other actors change their arguments over time. The Länder governments (brown), which have important veto power in Germany's federal political system, and the industry associations (red) shift their storylines and become a strong pillar of the pro-coal coalition in phase 2 and 3, while the federal government (purple) and some energy companies (blue) mobilize more and more pro-phase-out storylines over time. The government is of course the pivotal actor. While the Minister for the Environment argues in favor of phase-out over the entire time, the Ministry for Economic Affairs joins the D coalition in phase 3.

In the final phase, an important shift concerns a number of Länder governments representing coal mining regions: while they are strong voices in the pro-coal discourse coalition in phase 2 and 3, their positions shift in phase 4. After the topic has left the commission phase, they acknowledge the necessity of phase-out for climate reasons, but try to secure as much financial compensation as possible. In the final phase, only the industry associations remain as a strong pro-coal voice.

Many energy companies, which are very active proponents of pro-coal storylines in the first two phases, also change their position. Coal plant operator Vattenfall, for example, starts to restructure its assets in 2015/2016 and finally divests from coal-fired power plants in Eastern Germany. The utility company E.ON portrays coal as cheap and reliable in phase 1 and argues that efficient power plants may reduce emissions, possibly in conjunction with CCS technology. Later on, however, e.on does not contribute to the discourse any more. A detailed look at the positioning of specific actors over time is provided in the actor congruence networks contained in Fig. A2 (see appendix).

The preceding analyses indicate that the D coalition was more stable over time than the L coalition, more ideationally congruent (since 2013), and broadened its actor base up to the point that the strategically most important actors supported a coal phase-out. This seems to suggest that the D coalition was successful. The phase-out policy decision can be regarded as an institutionalization of delegitimizing storylines. However, examining the phase-out policy more closely supports a more nuanced interpretation, demonstrating that both coalitions were successful in shaping the policy. In the next section, we trace which storylines left an imprint on the phase-out law.

4.4. *Institutionalization of storylines in phase-out policy*

While the climate impact of coal (D1) was already persistently emphasized since the early 2000s (see Fig. 3), the government and other influential actors discussed coal predominantly in the context of security of supply (L4) at that time. It took until 2014/2015 (phase 2) for the climate storyline to be gradually endorsed by relevant decision-makers at the federal level, including chancellor Merkel and the then Minister for Economic Affairs and Energy, Sigmar Gabriel. The Paris climate conference helped to elevate coal phase-out on the government's policy agenda. During this time, the focus of the debate shifted from the question *if* a coal phase-out would ever be enacted to *when* this would (need to) happen in light of Germany's international climate commitments. As part of the Paris climate goals in 2015/2016, the government also decided to mandate a multi-stakeholder expert commission to develop strategies for managing the structural change in regions affected by coal phase-out.[6] However, it took until the next government was formed in early 2018 that the commission finally started its work.

While the D coalition had reached a partial success by 2016 in the sense that the topic of coal phase-out had reached the state's decision center, its main goal was only achieved in July 2020. Interestingly and despite its dominance in the discourse, the climate storyline (D1) did not leave much of a mark in the coal phase-out law. Comprising 50 small-printed pages in total, the term "climate" only appears three times in the entire text (Coal phase-out law, 2020).

On the other hand, considering the phase-out law as institutionalized discourse, the pro-coal coalition appears to be partly successful as well. While it could not prevent the phase-out, three storylines (L3, L4 and L5) have left their imprint on the policy. The L coalition had reiterated that 'coal is cheap' (L3) particularly during the consultations of the Coal Commission (Phase 3, Fig. 3). Keeping aside the disputability of these claims, the phase-out law formulates the need to ensure a cheap electricity supply despite coal being phased out (Coal phase-out law, 2020 §2).[4]

Also, the security of supply (L4, coal is reliable) argument left a mark. It became prominent again in the discourse during phase 4. And while the Coal Commission had already proposed a cautious retirement path, policymakers implemented an even less ambitious phase-out. The argument about disruptions in mining regions (L5, unemployment) shaped the political process as well, especially in

[6] See https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Klimaschutz/klimaschutzplan_2050_bf.pdf

phase 3 and 4. For instance, the federal government deliberately chose two of the four chairs of the Coal Commission to represent the interests of lignite mining regions. This equipped the pro coal coalition with significant power. In the end, substantial compensation payments were not only specified in the phase-out law but also in a second law[7] to support regional change.

To summarize, the pro-phase-out coalition and its arguments became dominant in the public discourse, especially in the later phases. The phase-out decision is clearly a success of this coalition. However, key storylines of the pro-coal coalition were also institutionalized through policymaking.

5. Discussion and concluding remarks

5.1. Comparison with other studies on coal phase-out

Our study corroborates earlier analyses of actor positions and views regarding the future of coal in Germany (Leipprand and Flachsland, 2018; Müller-Hansen et al., 2021). Analysing the positions of 52 actors in 2015–2016, Leipprand and Flachsland (2018) also identified two opposing coalitions with arguments around climate, security of supply and suffering regions, which are very similar to the storylines we find. While the authors identified early indications of regime destabilization, they could not track whether the opposing actor groups were successful in institutionalizing their views. With our longitudinal perspective, which also included the formal policy process, we were able to track changes in the discourse and the institutionalization of storylines.

This allowed us to also identify strategic changes. Interestingly, the pro-coal coalition shifted their arguments very recently from outright opposition to a subtler rethoric demanding a 'careful' phase-out, effectively asking for more time and money. Such strategies have also been observed elsewhere as an element of "discourses of climate delay" (Lamb et al., 2020),[8] in which incumbents turn away from outright denial or opposition to acknowledging the general importance to act, while seeking to justify slow and inadequate action.[9]

Looking across countries, Germany shows a moderate level of climate ambition with its coal phase-out. The United Kingdom, for instance, intends to end coal-fired power generation in 2024 already. In contrast to Germany, however, the UK still plans to rely on nuclear energy and also gas still plays a key role for power supply (Brauers et al., 2020; Isoaho and Markard, 2020). Japan is at the other end of the spectrum: Arguments in favor of coal phase-out are still very new and scarce, and there are strong lock-in effects, weak opposition and a high level of legitimacy ascribed to coal (Trencher et al., 2020). Comparing storylines, health-related arguments were important for the discursive delegitimization of coal in the UK (Isoaho and Markard, 2020) and Ontario (Rosenbloom, 2018), but played hardly any role in Germany. Future research may help to better understand the conditions under which discussions about health co-benefits can help to accelerate energy transitions.

The comparative literature also highlights that political institutions in Germany better equip incumbents such as utility companies, energy intensive industries or unions to influence policymaking (Brauers et al., 2020; Rentier et al., 2019). Our study confirms that these stakeholders left their mark on the coal phase-out law, despite their discourse coalition being less stable with partly diverging storylines.

5.2. Merits and limitations of analysing discourse coalitions

With regard to the success of discourse coalitions and the institutionalization of storylines, our study largely confirms expectations about the role of coalition stability, ideational congruence and actor base. The D coalition not only appeared to be more stable and congruent, but also grew over time to include the most relevant and politically powerful actors in the final phases. This helps to explain why the coalition was eventually successful in that a coal phase-out was implemented. However, we also found that this success was limited with respect to the policy details. Therefore, we suggest distinguishing different layers of success: the overall policy decision and its details. Discourse analysis can provide good indications for the success of a coalition at the broadest level, but understanding how the policy details were shaped (and how the L coalition managed to get an almost 20-years long lifeline) requires complementary analyses. Factors such as incumbents' ties to policymakers, the allocation of seats in expert commissions or (un-)usual alliances are likely to play a role here (Duygan et al., 2021; Gray and Bernell, 2020; Smink et al., 2015).

This brings us to the merits and limitations of our work. Discourse analysis provides strong tools to identify the ideational aspects of political struggles. Yet, discourse analysis typically tends to focus more on the substantive layer of discourse, treating actors and their discursive relations in a somewhat secondary fashion. This is where DNA adds a lot of value: We can use DNA to identify and visualize discourse coalitions and coalitional dynamics over time, and measure key characteristics in a formal way. Combining qualitative discursive analysis and quantitative actor-network analysis, DNA provides a transparent and replicable toolset that other transition scholars may find valuable to systematically investigate i) how arguments, frames or storylines emerge, ii) how coalitions coalesce around these shared constructs, and iii) how discursive dynamics differ between sectors or jurisdictions.

A potential shortcoming of discourse analysis, if applied in isolation, is that the strong focus on storylines and ideational elements may lead to an underappreciation of material aspects such as the economic or technical viability of technologies. The dead-end

[7] Strukturstärkungsgesetz Kohleregionen, see http://www.bgbl.de/xaver/bgbl/start.xav?startbk=Bundesanzeiger_BGBl&jumpTo=bgbl120s1795.pdf

[8] See https://www.celinekeller.com/discourses-of-climate-delay for a comic visualization of climate delay.

[9] See also the phase model of regime destabilization by Turnheim and Geels (2012) in this regard.

discourse around CCS (D2/L2), for example, is closely related to the collapse of early expectations and unsuccessful pilot projects. Similarly, the recent maturation of renewable energies certainly had a great influence on the D4 storyline ("Coal is not needed"). As renewables diffused rapidly at increasingly favorable costs, it became much harder to argue in favor of coal to keep the lights on.

A limitation of our study is that we rely on a single data source: newspaper articles. Public discourse takes place in many different arenas, also including social media, town halls, or street protests (Hilgartner and Bosk, 1988). Newspaper articles do not cover all of these equally. While our analysis picked up some unconventional actors (for example, the Fridays for Future movement appears as a prominent actor in phase 4, Fig. A2, number 50), it is likely that we have missed actors and arguments. Further research might want to dig deeper here, e.g. by comparing insights from traditional and new media channels (Stutzer et al., 2021).

5.3. Conclusion and outlook

Our study illustrates how the politics of sustainability transitions play out as discursive struggles over technology legitimacy. As such, the decision to phase-out coal in Germany was preceded by a decades-long discursive delegitimization of coal, which mainly relied on the storyline "Coal is bad for the climate." Actors representing the incumbent regime, whose business models and assets would be threatened by a phase-out decision, countered these efforts using various storylines to (re-)legitimize coal. While the decision to phase-out coal by 2038 may be seen as a success of the coal delegitimizing discourse coalition, incumbents were able to leave their imprint on the adopted policies as well, buying more time for a slower transition to renewables than what would be required to meet international climate goals.

With its unique perspective on discourse coalitions and discourse dynamics, DNA provides novel insights into the politics of transitions. It can nicely complement related approaches that analyze policy change in the specific context of sustainability transitions (Kern and Rogge, 2018; Markard et al., 2016a; Roberts et al., 2018). Also, DNA is well compatible with longitudinal analyses (a trademark of transition studies) and with the study of actors and their policy preferences, which are also central for transitions research. While we have explored how DNA can be mobilized to study how technologies are (de-)legitimized, e.g. in order to gain public and policy support, the full potential of DNA goes beyond what we have illustrated here (Brugger and Henry, 2021). For example, further research may specifically focus on the role of bridging actors in brokering compromises between competing coalitions. DNA can also be used to study competing socio-technical configurations and the actors that support them (Heiberg and Truffer, 2021).

Declaration of competing interest

There are no competing interests.

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Table A1
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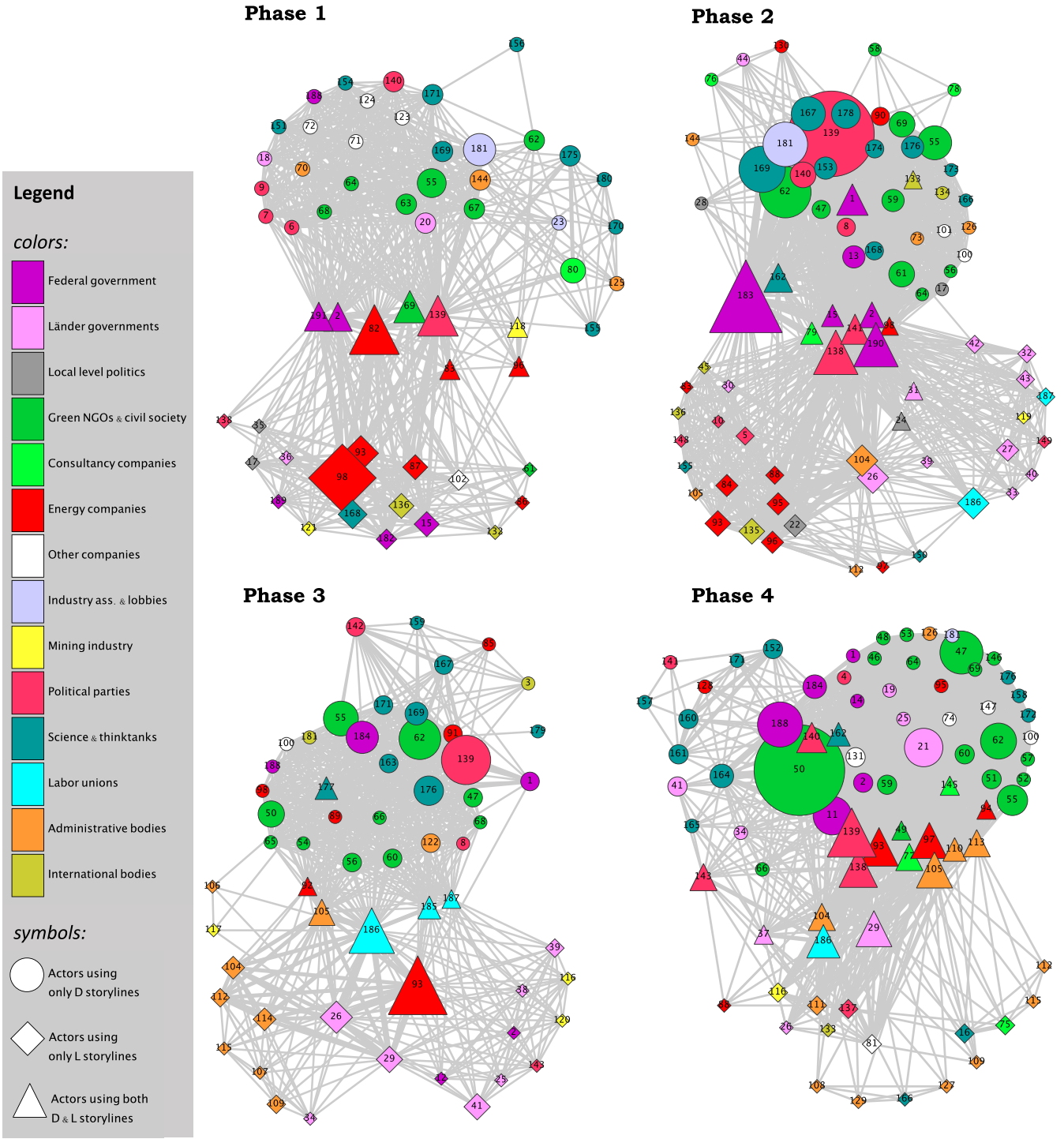

Fig. A2. Actor congruence networks with a focus on prominent actors. Node size corresponds to frequency of statements. Circles represent actors exclusively using D storylines; diamonds represent actors exclusively using L storylines; and triangles represent actors using both D and L storylines. Link strength corresponds to the number of same storylines two actors (symbolized by adjacent nodes) mention in the discourse. Numbers are abbreviations for actors (see appendix B for number codes).

number 191001–210930).

Appendix

Table A1, Fig. A2.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.eist.2021.08.001.

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