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Post-carbon energy governance and the political economy of the German coal phase-out

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by

Andrea Teresa Furnaro Lobos

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ABSTRACT OF THE DISSERTATION

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Professor Kelly Ann Kay, Chair

In July 2020, Germany adopted the Coal Exit Law, which requires all existing coal power capacity to be phased out by 2038, at the latest. This coal exit plan was sudden and unexpected, as the idea of phasing out coal was far from the political agenda in recent years. By putting into conversation theories of capital devaluation, critical energy studies, regulation theory, and debates on the socioecological fix, this dissertation analyzes the political-economic conditions that explain why and when the Coal Exit Law emerged. This research introduces the notion of moral devaluation, which can inform empirical research on the institutional arrangements through which the phase-out of fixed fossil fuel capital is resisted and organized in different contexts. This project was based on 21 months of fieldwork and a multi-method approach that included 90 interviews with actors related to the German coal phase-out process, as well as an historical examination of periods of coal devaluation. The resulting analysis reveals the continuities between Germany’s Coal Exit Law and its long tradition of delaying the devaluation of coal. Beyond dualistic market- vs. policy-based interpretations of coal exit drivers, the multistakeholder and consensual approach used in Germany is described from the perspective of its mediating role in addressing an ongoing devaluation affecting the energy industry and managing a dual legitimation crisis affecting the federal government.

The dissertation of Andrea Teresa Furnaro Lobos is approved.

Eric Steward Sheppard

John A. Agnew

William Clarence Boyd

Kelly Ann Kay, Committee Chair

University of California, Los Angeles

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LIST OF ACRONYMS

AfD	Alternative für Deutschland
BDA	Bundesvereinigung der Deutschen Arbeitgeberverbände (Confederation of German Employers' Associations)
BDEW	Bundesverband der Energie- und Wasserwirtschaft (Federal Association of Energy and Water Management)
BDI	Bundesverband der Deutschen Industrie (Feberation of German Industries)
BMUV	Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz (Federal Ministry for Environment, Nature Conservation and Nuclear Safety)
BMWi	Bundesministerium für Wirtschaft und Energie (Federal Ministry for Economic Affairs and Energy)
BUND	Bund für Umwelt und Naturschutz Deutschland (Federation for the Environment and Nature Conservation Germany)
CDU	Christlich Demokratische Union Deutschlands (Christian Democratic Union of Germany)
CSU	Christlich-Soziale Union in Bayern (Christian Social Union in Bavaria)
DGB	Deutsche Gewerkschaftsbund (German Trade Union Confederation)

DIHK	Deutscher Industrie- und Handelskammertag (Association of German Chambers of Industry and Commerce)
DNR	Deutsche Naturschutzring (German conservation group)
EnBW	Energie Baden-Württemberg (Energy Baden-Württemberg)
EU ETS	European Union Emissions Trading System
FDP	Freie Demokratische Partei (Free Democratic Party)
FNA	Federal Network Agency
IEA	International Energy Agency
IGBCE	Industriegewerkschaft Bergbau, Chemie, Energie (Industrial Union Mining, Chemical, Energy)
LEAG	Lausitz Energie Kraftwerke Aktiengesellschaft (Lausitz Energy Power Plant Corporation)
MIBRAG	Mitteldeutsche Braunkohlengesellschaft mbH (Central German Lignite Company)
NRW	North Rhine-Westphalia
RWE	Rheinisch-Westfälisches Elektrizitätswerk Aktiengesellschaft (Rhenish-Westphalian Electricity Corporation)
SPD	Sozialdemokratische Partei Deutschlands (Social Democratic Party Germany)
VKU	Verband kommunaler Unternehmen (German Association of Local Public Utilities)

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VITA

Andrea Teresa Furnaro Lobos

Education

MA	Geography. Syracuse University, New York, US, 2016 – 2018
MA	Social Sciences. University of Chile, Santiago, Chile, 2013 – 2015
BA	Philosophy. Catholic University of Chile, Santiago, Chile, 2010 – 2013
BA	Sociology. Catholic University of Chile, Santiago, Chile, 2007 – 2012

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Furnaro, A., & Yanguas-Parra, P. 2022. A Global South Perspective on Stranded Regions: Insights from the Decline of Coal Mining in Cesar, Colombia. Economics of Energy & Environmental Policy, 11(2), 27-48. https://www.iaee.org/en/publications/eeeparticle.aspx?id=427

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TEACHING EXPERIENCE

Teaching Associate. Theory and History in International Development, UCLA, Int. Institute (online) 2021

Teaching Associate. People and Earth's Ecosystems, UCLA, Geography (online) 2020

Teaching Assistant. Cultural Geography, UCLA, Geography 2020

Teaching Assistant. Globalization, markets and regional development, UCLA, Geography 2019

Teaching Assistant. Environment and Society, Syracuse University, Geography 2017

Teaching Assistant. Qualitative Research I, University of Chile, Sociology 2014

CHAPTER 1. INTRODUCTION

1.1. Exit dates in motion

Contemporary economies are rapidly changing the ways in which they are producing and using energy, with a massive incorporation of renewable energies. However, the degree to which the current expansion in renewable energies represents a genuine energy transition rather than a mere energy expansion is unclear. This is true on a global scale as well as at the level of large national economies that are quickly incorporating renewables without an equally rapid phase-out of fossil fuel consumption (IEA, 2018). While many countries have effectively rolled out extensive policies to support the expansion of renewables energies, equally large efforts to shut down fossil-fueled energy systems have not yet emerged in a comparable fashion, showing that the destabilization of fossil fuel energy regimes operates with logics that are different than the capacity of cheaper lower-carbon energies to displace their use.

Germany is unparalleled in its capacity to plan massive shutdowns of energy infrastructure. Between 2011 and 2021, the country agreed on the total shutdown of two key sources of its electricity mix: nuclear energy by 2022 and coal power generation by 2038. On July 8, 2011, legislators issued the Amendment of the Atomic Energy Act (13th AtG amendment), which limited the operation of nuclear power plants to December 31, 2022 (BMUV, 2019). This was a very significant decision, as nuclear energy represented 18% (107,971 GW) of the total electricity produced in Germany in 2011 (IEA, 2022a). Moreover, this Act established the permanent shutdown of the country's seven oldest nuclear reactors (8 GW in total). This almost unanimous decision was prompted by the nuclear disaster at the Fukushima Daiichi Nuclear Power Plant that occurred in Japan on March 11, 2011 after the Tōhoku earthquake and tsunami.

However, the nuclear exit decision was also based on debates and strong opposition expressed by different sectors of the German society for the security, health, and environmental risks associated with nuclear power, which were at the center of the German environmental movement since the 1970s (von Hirschhausen, 2018; Gründinger, 2017). The Amendment of the Atomic Energy Act of 2011 was part of a broader energy policy implemented during Angela Merkel's government (Chancellor of Germany between from 2005-2021), the famous *Energiewende*, or energy transition policy, which aimed to deeply transform the German energy sector through the reduction of fossil fuel and nuclear energy use and the rapid incorporation of renewable energies (Schreurs, 2013).

At the end of the decade, another massive phase-out of energy infrastructure was planned in Germany, which would lead to the final shutdown of coal mining and coal power production. On July 3, 2020, the Coal Exit Law was adopted, which required all existing coal power capacity to be phased out by 2038. As a result, in 2020, Germany was tasked with replacing in just a couple of decades, 41% of the electricity generated that year (601.9 billion kWh): 114 billion kWh of lignite or brown coal (18.9%), 57.5 billion kWh of hard coal (9.6%), and 75.1 billion kWh of nuclear energy (12.5%) (AGEB, 2022). In both the nuclear and coal phase-out plans, multistakeholder commissions were established by the federal government, more specifically by Chancellor Angela Merkel, as key governance tools to consensually discuss and provide recommendations for the future of both energy sectors. The Nuclear Commission, formally named Ethics Commission for a Safe Energy Supply, operated between April 4 and May 28 of 2011, and was formed by prominent scientists, politicians, religious leaders, and industry representatives (Ethics Commission, 2011). The Coal Commission, formally named Commission for Growth, Structural Change and Employment, operated between June 26 and October 31, 2018, and was formed by a wider group of representatives of environmental organizations, industry organizations, trade unions, and coal regions (BMWi, 2019).

The Coal Exit Law of 2020 took most of the recommendations from the Coal Commission into account, of which the setting of 2038 as the latest possible date to fully phase out the use of coal-fired electricity in the country was of particular importance. In the case of existing hard-coal power capacities (18.1 GW in 2019), the scheduling of this process is based on several tendering rounds through which coal-fired operators that offer the lowest bids are paid a financial compensation (or "close-down premium") to shut down power stations. These tenders will be used until 2027, a year after which it is expected that there will not be enough players in the market to participate in a competitive bidding system. After 2027, the scheduling of remaining closures will be defined on a regulatory basis. In the case of existing lignite-fired stations (21.6 GW of capacity in 2019), given that operators are also owners of lignite mines, which correspond to only two companies (RWE and LEAG), bilateral negotiations were organized to define compensation payments: 2.6 billion euros for RWE and 1.75 billion for LEAG. In addition to the Coal Exit Law, the Act on Structural Change in Coal Mining Areas was established. This provides a regulatory framework to ensure financial support for regions that will be economically and socially affected by the coal phase-out process, particularly the three remaining lignite regions in Germany (Lusatia, Central Germany, and the Rhineland), as well as regions where coal-fired stations play an important economic role. The Act involves a package of 40 billion euros to be used until 2038 (BMUV, 2022).

Large scale shutdowns of operative energy infrastructure have happened before in the history of industrialized economies, especially given technological competition as well as during economic crises and wars (e.g., Turnheim & Geels, 2012; Dublin & Licht, 2016). Germany itself offers relevant examples, with the rapid decline in coal mining production during the 1960s given increasing international competition from alternative fuels as well as with the rapid decline in lignite production during the 1990s given privatization after East and West German reunification (Oei et al., 2019). What is new in the current nuclear and coal exit processes is the fact that, unlike the examples above, the phase-out is based on the use of legally binding bans on the future use of these specific energy sources, closing the option (at least by now) of a resurgence after the exit dates. However, Germany is not unique in terms of planning the total shutdown of specific types of energy infrastructure. Other countries have also recently planned large-scale phase-outs of both nuclear and coal power. Spain and Switzerland have nuclear exit plans (La Razón, 2022; Osorio and Van Ackere, 2016) and several coal phase-out plans have been announced since the mid-2010s in Europe, with large volumes being phased out in the UK, Italy, and the Netherlands (EBC, 2022). The German case, however, represents the highest amount of electricity capacity involved (see Table 1 for a country comparison of capacities involved at the time of enacting the German exit plan).

Recent scholarship has increasingly focused on the fact that, across the globe, investments in the extraction and production of fossil fuel energy will need to be shut down before their expected end life, and even before the investments are recovered, to mitigate the climate crisis (McGlade and Ekins, 2015; Welsby et al., 2021). This premature shutdown of projects increases the risk of stranded assets in the energy sector as a result of the energy transition and the implementation of climate policies. Stranded assets are those that lose "economic value well ahead of its anticipated useful life, whether that is a result of changes in legislation, market forces, disruptive innovation, societal norms, or environmental shocks" (Generation Foundation, 2013). The burgeoning literature on stranded assets has described the possible economic impacts that they can generate not only among financial actors, but also in fossil fuel-rich countries and regions (Bos and Gupta, 2018; Caldecott and McDaniels, 2014; Furnaro & Yanguas, 2022). However, shutting down modern, costly, and in some cases, highly efficient operations and infrastructures, represents not only an increasing risk, but also an economic and political challenge, given existing vested interests resisting this process. Therefore, societal changes that can increase the risks of stranded assets take place in tandem with multiple practices to resist devaluation.

Germany's organization of a final shutdown of energy infrastructure will prove instructive for other countries trying to imagine their own ways out of fossil fuel dependence. More conceptually, analyzing the drivers that led to the German coal phase-out plan can help improve understanding on how capitalist economies can advance towards this transformation. Influenced by these questions, the first goal of this dissertation was to explore the political and economic conditions that explain why and when the German Coal Exit Law emerged.

Table 1. Phase-out plans in the ten countries with highest coal power capacity when the coal exit plan was discussed and enacted

	Coal Consumption 2019			**Coal Extraction 2018**			**Phase-out plan announ-ced**
Country	**Operating (MW)**	**% of world total**	**World ran-king**	**MT**	**% of world total**	**World ranking**	
China	1,004,948	49.1%	1	1828.8	46.69%	1	No
United States	246,187	12.0%	2	364.5	9.31%	2	No
India	228,964	11.2%	3	308	7.86%	4	No
Russia	46,862	2.3%	4	220.2	5.62%	6	No
Japan	46,682	2.3%	5	0.6	0.02%	37	No
Germany	44,470	2.2%	6	37.6	0.96%	11	Yes
South Africa	41,435	2.0%	7	143.2	3.66%	7	No
South Korea	37,600	1.8%	8	0.6	0.02%	38	No
Indonesia	32,373	1.6%	9	323.3	8.25%	3	No
Poland	30,870	1.5%	10	47.5	1.21%	10	No
Subtotal	1,760,391	86.1%		3274.3	84%		
Rest of the world	284,440	13.9%		642.5	16%		
World total	2,044,831	100.0%		3916.8	100%		

Sources: Global Coal Plant Tracker https://endcoal.org/ and BP Statistical Review http://www.bp.com/statisticalreview

The German case is particularly interesting for high-emitting industrialized economies, such as the United States or China, where a national policy to set an end date for coal still feels like a politically improbable outcome. For the same reason, however, the German consensually-based approach and planning capacity can seem exceptional and deeply embedded in the peculiarities of this country's political, economic, and environmental institutions and cultures, and therefore not very illustrative of how phase-out process may take place in other contexts. Yet, Germany's planned phase-out approach has also been characterized by high flexibility, which as this dissertation will show, has to do with some of the widely shared complexities of shutting down energy infrastructure.

The best example of this flexibility is most likely the several U-turns that the nuclear phase-out plan has experienced over time. The 2011 act to phase out nuclear power was preceded by a similar policy that took place in 2000-2002. In this former version, the federal government at the time, formed by a coalition between the Social Democratic Party (SPD) and the Green Party (Germany's first red-green coalition), sought a gradual phase-out of nuclear power by around 2022, a policy deeply influenced by the Chernobyl crisis a decade and a half ago (Schreurs, 2013). In 2010, however, almost ten years after the first nuclear phase-out plan was enacted, a much more pro-nuclear coalition was in government, led by Chancellor Merkel and formed by the conservative parties (the Christian Democratic Union, or CDU, and the Christian Social Union, or CSU), and the liberals (the Free Democratic Party or FDP). They extended the lifetime of nuclear power stations by 12 years on average, arguing its importance for industrial growth, to then, just one year later, reversing this policy and implementing the latest nuclear phase-out plan, which defined 2022 as the end year of nuclear energy, and took place in response to not only the Fukushima disaster (Gründinger, 2017), but also a broader legitimacy crisis affecting the ruling parties (Schreurs, 2013).

In the case of the coal phase-out, in 2021, the *Ampel* (or traffic light) coalition composed by the Greens, FDP, and SPD parties, replaced Merkel's government, and promised that new mechanisms would be implemented to accelerate the coal exit date already defined by the Coal Exit Law, from 2038 to 2030. This decision took place after mounting critiques against 2038, the exit dated proposed by the coal commission and included in the Coal Exit Law, for not being in line with the Paris Agreement. During 2022, when Russia's invasion of Ukraine constrained the supply of coal and natural gas to Germany, creating a sharp increase in the prices of fossil fuels that prompted an energy crisis all over Europe, this 2030 coal exit date has widely been put into question in the public opinion. In this context, some actors have started to demand an extension to nuclear energy (Höland, 2022; Polansky, 2022). Although the government has not reconsidered its 2030 compromise at the time of writing, several coal-fired power plants scheduled for shutdown have restarted operations, with 2.6 gigawatts of planned shutdowns being postponed (Polansky, 2022).

The uncertainty of shutdown trajectories reveals important dimensions of the political economy of these processes, in which defining exit dates, a characteristic practice of the German approach, only represents the tip of a much more complex iceberg. The goal of this dissertation was to make sense of the causes of the coal exit agreement as one small piece of a wider coal phase-out process. From this perspective, the emergence of the first legally binding coal exit date with the enactment of the Coal Exit Law in 2020 represents only one moment in a story that began before the 1960s, when the structural crisis of the coal industry unfolded, and whose end is hard to fully predict. In this dissertation, I highlight the uncertainties and contingencies of this long exit process on par with Germany's astonishing capacity to plan its energy past, as a key approach to avoid exaggerating the relevance of the "policy moments" (when exit policies and laws are formally discussed and enacted) and therefore of the policy driven character of the coal phase-out.

The second goal of this dissertation had to do with the fact that Germany's climate leadership has been overshadowed by the slower pace by which the country has reduced its coal dependence in relation to the rapid incorporation of renewable energies since the 2000s, and despite the very strong pressures exerted by the German climate movement. In the late 2010s, Germany's paradoxical situation was widely exposed, highlighting its green reputability when it comes to renewables, but a much dirtier one when it comes to coal (Jungjohann & Morris, 2014). In this context, the coal exit agreement, based on abundant compensations for coal companies and a final date that is not in line with the Paris Agreement, raised sharp critiques from climate activists in Germany and beyond, who suspected that the policy's primary goal was to bail out coal companies rather than accelerating the country's decarbonization (FFF, 2022; XR, 2020). Rather than trying to resolve this conundrum, the second goal of this dissertation was to make sense of it, by exploring what the political and economic forces and institutional mechanisms that led to a coal exit agreement were, taking into account that this agreement can be interpreted as impressive for committing a massive and costly shutdown of energy infrastructure, yet also as slow when compared to the declining economic, environmental, and political viability of coal-fired electricity.

1.2. A political economy of devaluation

1.2.1. The lack of a political economy of fossil fuel phase-outs

While not many years ago, various academic articles from social scientists critiquing the apolitical nature of the scholarship on energy transitions were published (Murphy 2015; Paul; 2018), there is now increasingly abundant research available employing political-economic approaches to study energy transitions (e.g., Newell, 2021; Pearse, 2021; Baker et al 2014). This body of work offers a useful vocabulary to understanding how deep transformations in energy systems can take place or be resisted, making evident the shortcoming in approaches that predominantly focus on techno-economic factors. Energy geographers have been playing an important role in this political-economic turn, by emphasizing the centrality of space and nature in energy transitions (Bridge and Gailing, 2020; Bridge et al., 2013; McCarthy, 2015). This dissertation contributes to this scholarship by addressing three shortcomings that, as I argue below, limit our capacity to better grasp phase-out process, a central part of genuine low-carbon energy transitions.

Phase-out as a residual category. Most research on the political economy of energy transitions focuses on the phase-in of renewable energies, leaving the phase-out of fossil fuels as a relatively residual aspect. This gap can be attributed to, at least in part, empirical scarcity, with coal being the only fossil fuel that only recently started to be phased-out in some countries and regions (Diluiso et al., 2021). This research gap, however, has epistemological roots as well that stem from the predominant assumption that energy transitions are driven by the technological development of renewable energies (Davidson, 2019; David, 2017). This neo-Schumpeterian reading has led to an inclination to see the destabilization of fossil fuel industries as a mere result of technological replacement (cf. Bridge, 2018) and to the preference, even by critical energy scholars, to analytically follow new forms of value creation in the energy sector, and accompanying forms of dispossession and exploitation, leaving processes of "exnovation" (David, 2018) as a residual category. This tendency resonates with what some social scientists have described as the rejection of material forms that are considered unproductive or unable to create profit from any form of further classification (Gidwani, 1992; Whitehead, 2010). In the case of energy transition studies, theoretical accounts of the political economy of phasing out fossil fuels, as an active and multidimensional processes, are scant (for an exception, see Rentier et al. 2019; Brauers et al. 2020). This also includes a lack of accounts of the geographies of phasing out fossil fuels, posing questions around the role of space in promoting and shaping these processes, and of these processes creating and remaking space. This dissertation addresses these spatial questions by analyzing how the particularities of Germany's political geographies, including its federal organization, can balance power dynamics and address legitimacy issues associated with the coal sector, as well as how German reunification and the associated consequences of industrial and coal decline have influenced the recent discussions around a coal exit plan.

A political economy of stakeholders. An important portion of the scholarship on the political economy of energy transitions focuses on the politics of enabling and obstructing actors, where macro-level (e.g., capitalist logics and rules) and meso-level (e.g., geohistorical modes of governance and institutional arrangements) issues are often left implicit. Several case studies based on this narrow understanding of political economy have recently been published, and center around the disputes of competing interests among incumbent fossil fuel and industrial sectors seeking to keep the status quo, environmentalist groups and emerging renewable energy companies trying to accelerate the energy transition, and politicians seeking votes and legitimacy (Strunz et al. 2016; Hess and McKane, 2017; Brauers and Oei, 2020). Although vested interests are fundamental to understanding the political economy of energy transition, reducing the analysis to a stakeholder interest dispute limits our capacity to recognize the role of marco- and meso-level dimensions. When macro- or meso-level institutions, in the sense of more perduring areas of social action, are explicitly considered by the scholarship on the political economy of energy transitions, they tend to be seen as "institutional actors" in a power dispute (Hess and McKane, 2017), or as well-defined and static frameworks defining how actors resolve energy issues in specific contexts. The latter includes a tendency to take for granted the institutional frameworks described by the “varieties of capitalism” school in structuring energy struggles in specific ways – for example, through the rules of the market in the UK’s liberal market form of capitalism and through political networks in Germany’s coordinated market economy (Rentier et al. 2019; Brauers et al. 2020; Ćetković & Buzogány, 2016). Less discussed, however, is how flexible institutional aspects modify and are modified by changes in energy systems.

External political-economic relationality. Although the recent boom in political-economic analyses on energy transitions has meant a greater focus on the relationships between political and economic factors, there is still a tendency to see both as separate realms. The spheres of production, distribution, and reproduction vs. the spheres of political legitimacy and state relations are seen as relating externally, rather than as mutually constitutive (Geels, 2014; Brauers et al., 2020; Mrozowska et al., 2021). This view tends to reproduce the idea of the economy, where market energy relations are constituted, as a pure and distinct realm, which only comes into contact with the political realm later. In this dissertation, I aim to show that this view is not only conceptually flawed but also empirically unsatisfactory, as it gives the illusion that phase-out processes can be clearly classified as policy- vs. economically-driven. However, it is in the specific ways that these factors are mutually constituted and reconstituted where we can find some of the most interesting aspects to explain how and when phase-out processes take place.

1.2.2. The moral devaluation of coal

To address these shortcomings, this dissertation puts into conversation diverse variants of the scholarship on the political economy of energy transitions, particularly those that include explicit references to the role of meso- and macro-level institutions (Baker et al., 2014; Haas, 2019) with

Marxist accounts of capital devaluation (Marx, 1993; Smith, 2017; Harvey, 1982). The latter offers a more positive ontology on rules of devaluation, some of which are deeply associated with the mechanisms through which the phase-out of energy infrastructure can be promoted and resisted in capitalist economies (Carton, 2019). One of the main takeaways of this dissertation is that the energy transition is shaped by the ways in which capitalism creates and destroys value. Therefore, if we want to cast light on the political economy of energy transitions, we need to dive into the logics of valuation and devaluation. This dissertation focuses on the latter and on the particularities of coal devaluation in Germany. For this, engaging with theories about the roles of energy and fossil fuels in capitalism was key (Malm, 2016; McCarthy, 2015; Huber, 2011), given that, although the Marxist literature on devaluation offers useful accounts of the general dimensions of capital and fixed capital devaluation, the specificities associated with the energy sector are lacking.

Moreover, to overcome the limited role that Marxist accounts on devaluation provide to describe more-than-economic factors of capital devaluation, the notion of moral devaluation is proposed, an idea that emphasizes the role of social pressures such as the ones exerted by pro- and anti-coal groups in shaping phase-out processes. These social pressures are understood in relation to the role of market and technological factors. The notion of “moral devaluation” is based on the term “moral wear and tear” used by Marx to differentiate fixed capital devaluation brought about by social causes, especially economic competition, from devaluation caused by material depletion. In this dissertation, the notion of moral devaluation also includes other social drivers of fixed capital devaluation beyond the market. This notion also recognizes, as energy geographers have for some time, that technologies, and therefore technical depletion, are always socio-technical (Bridge, 2018).

This notion of moral devaluation relates to current debates about the risk of stranded assets in several ways. First, the risk of energy assets becoming stranded increases as the moral devaluation of fossil fuels also increases. The current puzzle for capitalist economies is how to accelerate the moral devaluation of fossil fuels to mitigate the climate crisis while avoiding the economic and social costs of a massive stranding of energy assets. However, while the notion of stranded assets tends to emphasize the financial impacts of devaluation for asset owners and investors, and more recently for fossil fuel-rich countries and producing regions (Furnaro and Yanguas, 2022), the notion of moral devaluation emphasizes the role of capitalist relations and rules in creating and regulating the devaluation of fossil fuel infrastructure in specific ways. In other words, while the literature of stranded assets has focused on a risk-management approach to better mitigate the impacts of stranded assets in the energy sector by, for example, reducing exposure by divesting from or limiting investments in costly fossil fuel projects, the notion of moral devaluation offers a heuristic approach to examine the emergence and regulation of stranded assets in connection with broader political-economic conditions.

The social energy scholarship has shown that predominant interpretations of past energy transitions tend to oversimplify their causes. Technological evolution, the energy content of different fuels, and fuel discoveries and markets have been overemphasized. Meanwhile, issues such as the role of labor and industrial relations, the political and legal systems, moral concerns, and spatial relations, among others, have been underexplored (Malm, 2016; Mitchell, 2011). Past energy transitions are commonly seen as part of the organic evolution of technological transformations, embedded in market relations since at least the birth of capitalism. The emergent low-carbon energy transition, in contrast, is seen as the result of increasing awareness of the climate crisis and the unfolding of policy efforts to address it by promoting technological innovations (Nelson and Alwood, 2021). The few recent instances in which fossil fuels have been phased down, however, tend to be interpreted as defined by either technoeconomic or policy drivers (Rentier et al., 2019; Brauers et al., 2020). This dichotomy hides the multiple layers of complex energy social relations that drive phase-out processes and shape the political and policy debate and pathways taken. The fact that genuine energy transitions normally involve moral devaluation means showing not only that phase-out processes require devaluation as much as valuation, but also the multi-layered social dimensions of devaluation, which include technological, economic, legal, and market changes.

The notion of moral devaluation resonates with Sayer's (2000; 2007; 2019) view of critical political economy as an endeavor concerning the moral economy, i.e., the economy as shaped by norms beyond pure self-interests and economic valuation. Viewing energy transitions from the perspective of moral devaluation involves accepting that the devaluation of capital in the German coal sector cannot be fully grasped without considering issues of political legitimacy, memories, and ecological values, among other more-than-economic factors that define what energy decisions are understood as acceptable or not by different groups. More generally, genuine energy transitions today, effective in shutting down or reconverting carbon-intensive energy systems, involve moral devaluation. Following Sayer's (2019) idea of the moral economy as a form of critique, the notion of moral devaluation can also be understood as inherently normative, as it highlights the importance of a fast and socially equitable phase-out of fossil fuels to mitigate the climate crisis.

This aspect of the moral devaluation framework also resonates with current efforts to understand the conditions to create more just energy transitions. The literature on just energy transitions focuses on the equity aspects of low-carbon energy transitions, by analyzing not only how renewable energies are creating social and environmental impacts in regions where they are being installed, but also how the phase-out of fossil fuels is being associated to negative impacts in regions of fossil fuel extraction and energy production, such as economic decline, unemployment, emigration, and environmental degradation (Gürtler et al., 2021; Gürtler & Herberg, 2021; Galgóczi 2019; Furnaro et al., 2021). Marxist interpretations show how the rules of fixed capital devaluation are associated with concomitant impacts among workers, local communities, and the environment (Harvey, 1982). By following devaluation and its costs, the moral devaluation framework used in this dissertation to examine the German coal phase-out will highlight processes of distribution and transference of concomitant impacts among workers, taxpayers, ratepayers, and broader social groups.

I put the moral devaluation approach into dialogue with regulation theories, which are useful to connect macro-level analyses of the rules of capital devaluation with meso-level accounts on how energy laws and institutions change in relation to capitalists' crises (Lipietz, 1988; Boyer 2018; Haas, 2019). This dissertation is also inspired by institutionalist theories that, similar to Marxist and regulationist approaches, don't see energy conflicts as taking place in an institutional vacuum, but rather understand national cultures, norms, and institutions as "tool kits" (not inflexible recipes for action) (Granovetter, 2017: p.192).

Specific policies to regulate the devaluation of fossil fuels should be understood in relation to existing institutions to regulate capital devaluation in general, which are attached to different styles of economic and legal governance. Political economists have long recognized the major role of the legal system in different "varieties of capitalism." Germany's civil law is important to regulate capital devaluation through higher levels of non-market coordination in comparison with liberal market economies (Casper, 2001). The role that the law plays in devaluation in Germany makes the notion of moral devaluation particularly useful to describe this case as the legal system tends to more directly incorporate moral norms in the ways in which it regulates market relations. In contrast, liberal market economies fit better with common law regimes, which give less relevance to the state in providing economic solutions, including a reduced active role in incorporating societal pressures in the state regulation of devaluation (cf. Roe and Siegel, 2009; Casper, 2001).

I take an historical approach to the German coal phase-out, which helps interpret how some of these institutions are reproduced but also decoupled and recombined (Sorge, 2005). From this perspective, the Coal Exit Law represents a new assembly of complex combinations of existing and new economic and energy practices, therefore providing a central but much less coherent role of meso-level German institutions as often portrayed.

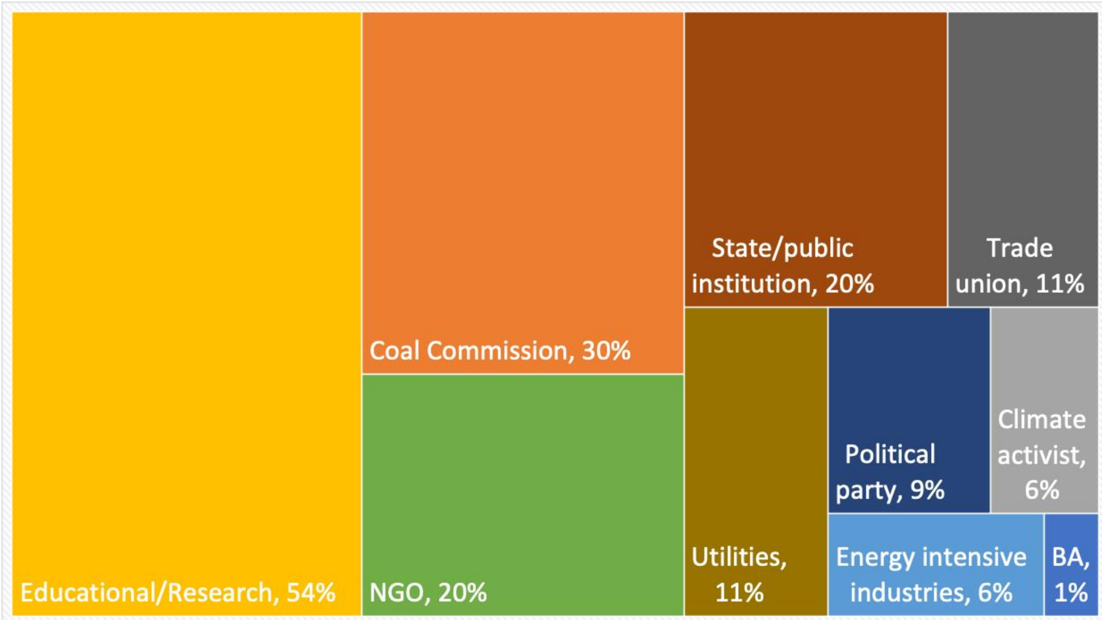
The approach presented in this dissertation pays attention to how micro, meso, and macro political-economic levels relate. This can be seen as a narrow cut, as it does not provide an extensive account of each layer (e.g., coal stakeholders, energy institutions, or capital devaluation), but rather it relates them to the extent that the connections are useful to make sense of the German coal phase-out. By offering this cut, this dissertation opens new understandings of the political economy of the German coal phase-out. However, recognizing the plurality of political economic analyses and their relevance, studies that focus on one of these layers and offer a deeper account of each of them are equally important to improving our knowledge of the different aspects of the political economy of energy transitions.

1.3. Methods

This dissertation offers an in-depth case study of the German coal phase-out. According to Noor (2008), a case study is a research approach that employs multiple methodologies and sources of evidence to investigate a contemporary phenomenon. Qualitative methods, including semi-structured interviews and document analysis, were supplemented by descriptive data analysis to provide a more general portrait of Germany's energy systems and the coal phase-out. Case studies are considered interpretative approaches because they emphasize processes and meanings rather than measurements and quantifications, being especially useful to understanding how and why things happen (Mabry, 2008). Therefore, this approach was useful to understanding why and how the coal phase-out was organized, and for considering contextual and historical factors. While case studies do not allow generalization, they provide an in-depth understanding of specific events and political processes, making them a valuable approach to developing theory (Baxter and Jack, 2008). This was important in the German case given how unprecedented this massive and nationally-organized coal phase-out process is globally. Therefore, although many results of this research can only be partially useful to generalize how phase-out processes can be organized in other contexts as well as in the case of other fossil fuels (oil and gas), by gaining a deeper understanding of the German coal phase-out, this research advances theoretical work on the political economy of phasing out fossil fuels.

This dissertation was based on 21 months of fieldwork in Germany, which were divided into two parts: preliminary fieldwork conducted between June and September of 2019, and a longer period of fieldwork that took place between February 2021 and June 2022. During my stays in Germany, I collaborated with the Coal Exit research group (now Fossil Exit) at the Technical Universität Berlin and Europa-Universität Flensburg. In total, I conducted 73 interviews with stakeholders related to the coal phase-out process. In addition, the transcriptions of 17 interviews conducted by researchers of the Coal Exit research group with members of the Coal Commission between October 2020 and January 2021 were analyzed as part of the primary data used in this dissertation. In total, 90 interviews were analyzed. In these interviews, the type of stakeholders included members of the Coal Commission, energy experts, NGO representatives, representatives of state and public institutions, members of trade unions, employees of utility companies, members of political parties, climate activists, and representative of energy intensive industries and of business associations. Figure 1 shows a summary of the types of actors represented in the sample. It is important to consider that several actors can be classified by more than one of these categories, which is especially common in the case of many university professors that were also members of the Coal Commission or that work for state or public institutions. Therefore, the sum of Figure 1 is 169% rather than 100% (see Appendix for the complete list of interviews). The specific institutions associated with each interviewee are not disclosed in this dissertation to protect the informants' identities. Although not all the interviews are quoted in this dissertation and not all of them directly contributed to the development of my main arguments, they informed my understanding of the German coal phase-out process and the analysis presented here.

Figure 1. Actors interviewed by profile



BA = “business association”.

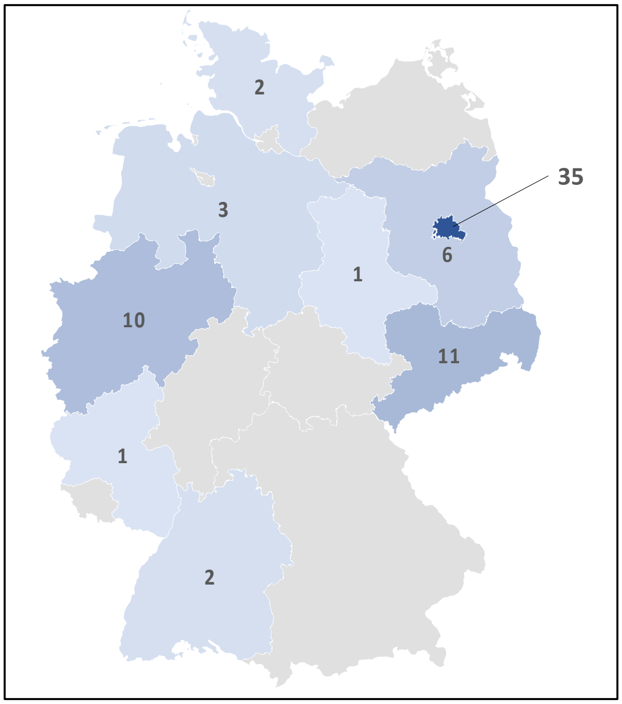
Purposive sampling was used in this project with the goal of achieving the maximum information and variation possible in interpretations about the conditions that allowed the coal exit agreement to take place (cf. Kemper et al., 2003). During preliminary fieldwork, experts on the topic as well as direct participants in the negotiations were contacted and interviewed. After that, specific actors that could help me fill gaps in my knowledge and triangulate interpretations were contacted according to their expertise (e.g., fuel markets, EU electricity trade, industrial relations, environmental law, etc.) or firsthand knowledge (e.g., representatives from specific NGOs, companies, or public institutions), with the aim of generating variation in the type of actors included in an iterative process of sampling and resampling.

Given that Covid-19 pandemic restrictions for in-person meetings were in place during most of the research, especially during 2021, most of the interviews conducted for this research (48/73) were held online, through a videocall using Zoom or Skype. A total of 19 interviews were conducted in person in Berlin, and six in the city of Leipzig. Although the pandemic limited my opportunities to conduct fieldwork in the different German coal regions, the use of Zoom meetings allowed me to reach informants located in different locations. I interviewed people residing in 9 of the 16 German *Länder* (federal states), including the four where active existing coal regions are located (Brandenburg, Saxony, Saxony-Anhalt, and North Rhine-Westphalia), as well as two stakeholders living abroad at the time of the interview (Switzerland and the Netherlands). See Table 2 and Figure 2 for a summary.

Table 2. Location of actors interviewed

Berlin	35	48%
Saxony	11	15%
North Rhine-Westphalia	10	14%
Brandenburg	6	8%
Lower Saxony	3	4%
Schleswig-Holstein	2	3%
Baden-Württemberg	2	3%
Saxony-Anhalt	1	1%
Rhineland-Palatinate	1	1%
Netherlands	1	1%
Switzerland	1	1%
Total	73	100%

Figure 2. Map of location of actors interviewed (by Länder)



All of the interviews were conducted in English and were between 40 and 90 minutes long. The interviews were semi-structured, and most of their content adjusted according to the expertise and experience of each actor and the specific knowledge gaps that I was trying to fill. However, the question of "why the coal exit agreement took place when it did and not before" was repeated among the first 18 interviews, after which a saturation in the responses was reached. All of the interviews, included those conducted by the Coal Exit research group, were analyzed using the qualitative software Atlas TI. This software helped me to organize and analyze the large quantity of material collected. An open-axial-selective coding process (Strauss and Corbin, 1990) was used in this analysis. The coding process is where the limitations in the existing approaches to study the political economy of energy transitions emerged. This is especially the case regarding the policy- vs. market-driven distinction that is common when analyzing coal phase-out processes. Therefore, coding played a key role not only for controlling evidence but also for generating theoretical reflections.

The analysis of documents and secondary literature on the German coal phase-out was a core aspect of this project. Part of the historical analysis used in this project was based on a research project conducted together with the Coal Exit research group, wherein we analyzed and classified policies implemented in Germany since the 1960s to support coal communities affected by the decline in production, especially in the Ruhr area (Furnaro et al., 2021). Moreover, for this dissertation, I analyzed more than 100 recently published documents (2010-2022), including news articles, policy reports, press releases, company reports, and laws. Working closely with the Coal Exit research group was fundamental to test my interpretations and ensure the validity and accuracy of my findings, particularly through periodic meetings to discuss preliminary results and to resolve specific inquiries about the data. The members of this research group participated as "critical reference group" in the research process (Pyett, 2003). They also provided me with language help to better translate some or some sections of the documents analyzed. Initial drafts of each of the sections included in this dissertation were read and commented on by at least two members of the Coal Exit research group to improve accuracy. The interdisciplinary character of this group was key to better understanding the various aspects of the political economy of the coal phase-out that I was interested in putting into conversation: the electricity and fuel markets, the policy frameworks, and the political conjuncture. Preliminary results were also discussed with energy geographers who are experts in the German case, particularly at the Brandenburg University of Technology in Cottbus, where one presentation of results was held and the comments received were used to improve the interpretation of the data.

1.4. Summary of this dissertation

The rest of this dissertation is organized into three main chapters. Each of these chapters was written as a standalone article, which analyzes different aspects of the political economy of phasing out coal.

The second chapter presents the theoretical approach used in this dissertation and was originally published as “The Role of Moral Devaluation in Phasing Out Fossil Fuels: Limits for a Socioecological Fix” in *Antipode*. By putting into conversation theories of capital devaluation, the scholarship on the socioecological fix, and critical energy studies, this chapter offers a conceptual framework to study the phase-out of fossil fuel energy infrastructure. The concept of moral devaluation is presented, which emphasizes the interaction of economic, political, and socioecological dimensions shaping the main forces, constraints, and regulatory mechanisms to devalue emission-intensive fixed capital. This chapter argues that the notion of moral devaluation is useful to inform empirical research on the institutional arrangements through which the devaluation of fixed fossil fuel capital is resisted and organized. Moreover, this notion complements current research on the possibility of a capital switch to renewable energies as a socioecological fix to the climate crisis and other entangled crises of capitalism, by emphasizing that the devaluation of fixed capital represents a constraining condition for the rapid emergence of a socioecological fix based on fixed capital formation in the low-carbon energy sector (Ekers and Prudham, 2018; McCarthy, 2015).

The third chapter presents an empirical analysis of the German coal phase-out by focusing on its temporal dimensions. It was originally published as “The last subsidy: regulating devaluation in the German coal phase-out” in *New Political Economy*. This chapter examines Germany’s coal exit plan. By putting theories of capital devaluation into conversation with regulation theory, this chapter reveals the continuities between Germany's exit plan and its long tradition of delaying the devaluation of coal. This chapter engages with relational political-economic approaches to analyze the German coal exit plan beyond the dualistic market vs. policy-based interpretation, which has been promoted by the coal industry to capture compensation payments. Rather, it will be argued that this plan, which in its current form is based on generous financial compensation to coal companies, can be understood as a way to regulate the ongoing devaluation affecting the energy industry and manage a dual legitimation crisis affecting the federal government.

The fourth chapter focuses on the geographical dimensions of devaluation. It analyzes the geographies of the German coal exit by looking at the spatial dimensions of coal devaluation. It argues that while the *Energiewende* has been described as having a national origin (Gailing and Röhring, 2016), central triggers of the national exit agreement have to do with devaluation pressures created by the combination of global relations in the fuel markets, the territorial bordering of electricity and carbon markets at the EU level, and place-based and multiscalar anti-coal networks. The role of place-based resistance to the past, relational, expected, and imaginary concomitant forms of devaluation in lignite regions is also described as a key spatial dimension of the German coal exit. It will be shown that the emergence of a coal exit agreement, which represents a national fix to address not only existing market devaluation forces but also a double legitimacy crisis for the government, was based on spatially uneven networked governance. This chapter concludes that the German case is relevant for the geographies of energy transitions for showing how multi-spatial strategies, the spatial organization of energy markets, and the territorial regulation of energy systems, shape the possibilities for the devaluation needed to accelerate the pace of the fossil fuels phase-out.

The fifth and last chapter provides some concluding remarks on the usefulness of theories of devaluation to understand low-carbon energy transitions as political economic challenges but also as heuristic approaches to better understanding how phase-out process take place from a relational and geographical perspective. It also explores future lines of inquiry that this research leaves open.

CHAPTER 2. THE MORAL DEVALUATION OF FOSSIL FUELS

2.1. Introduction

In recent years, several governments have announced plans to phase out the extraction and burning of coal. The Powering Past Coal Alliance (PPCA), a global initiative launched in 2017, brings together 33 national and 27 subnational governments committed to phasing out coal (Shearer et al., 2019). Fifteen European countries are implementing phase-out plans that will retire 72.8 gigawatts of coal power capacity by 2030 (Europe Beyond Coal, 2020). These initiatives, which are set to expand in the future, are important given that, under the Paris Agreement, unabated power generation needs to be reduced by 70% globally by 2030 and phased out completely before 2050. However, despite the fact that total capacity under construction is decreasing globally, countries such as China, Turkey, India, Vietnam, and Indonesia keep building new plants and increasing global coal production (IEA, 2020a). Moreover, while most of the phase-out agreements focus on coal, the expiration date of oil and natural gas is less clear. Investments in both of these fossil fuels keep growing despite estimations showing that in order to meet the Paris Agreement, 80% of all proven fossil fuel reserves should not be extracted, and most of the investments already made will have to be left idle (Bos and Gupta, 2018).

While there is robust literature that studies low-carbon energy transitions from a critical approach (Bridge and Gailing, 2020; Carton, 2017; Gailing et al., 2019; McCarthy, 2015), a key aspect of these transitions that has been understudied is the fossil fuels phase-out, which corresponds to the destabilization of GHG (greenhouse gases) emission-intensive energy systems through the complete or almost-complete removal of coal, oil, and natural gas extraction and burning (Rentier et al., 2019). As Bridge (2018:17) has observed, theories of exit in the energy transition scholarship are based on the assumption of a "general process of competition and a squeezing, normally via policy, of the commercial space for incumbent energy systems". Much less analyzed is "the process by which dominant and seemingly-durable actors and institutions come into question and start being abandoned". Therefore, more attention needs to be paid to the phase-out of fossil fuels, a process related to but not always correlated with the expansion of renewable energies.

This paper offers a conceptual framework, in the sense of a tentative theory to study the fossil fuel phase-out by putting into conversation the work of Marxist geographers interested in capital devaluation (Harvey, 1982; Smith, 2017), with critical energy studies (Carton, 2017; Malm, 2016; McCarthy, 2015), and the scholarship on the socioecological fix (Ekers and Prudham, 2015; 2017; 2018). Critical energy studies have developed rich accounts of the economic, political, and cultural mechanisms that reproduce the fossil fuel energy regime and hinder its replacement by low-carbon energies (e.g., Unruh, 2000). This scholarship has recently started to incorporate the idea of socioecological fixes to conceptualize the relationships between socioecological crises of capitalism and changes in energy systems (Furnaro, 2020; McCarthy, 2015; Spivey, 2020). However, to gain a better understanding of the possibilities of socioecological fixes in the context of the climate crisis, the interest in "fixed capital formation" (Ekers and Prudham, 2018) in the lower-carbon energy sector, which has been at the center of these discussions, needs to be complemented by more analysis on the role of fixed capital devaluation in the phasing out of fossil fuels.

With the aim of contributing to this analysis and drawing on Marx's notion of "moral wear and tear," the conceptual framework presented in this paper is organized in three main sections, which examine different devaluation forms, forces, and mechanisms, respectively. The next section starts by distinguishing capital, fixed capital, progressive versus periodic, and individual versus general devaluations. After these, the notion of moral devaluation is introduced. The paper then analyses different interrelated forces devaluing fossil fuels, particularly market, political, and biophysical forces. Different modes of regulating devaluation are examined in the following section. The final section presents some concluding remarks on the usefulness of this framework and relevant areas for future research.

The moral devaluation framework introduced by this paper can be used in empirical research to better envision institutional arrangements through which the devaluation of fossil fuels is resisted and governed, and its outcomes disproportionally distributed. Rather than settling imaginations of the possible, this framework seeks to be malleable both to and by empirical research as well as spatial, sectoral, and technological differences, while at the same time attentive to commonalities in political economic logics shaping phasing-out processes. The underlying argument sustained by this paper is that the devaluation of fixed fossil fuel capital (i.e., fixed capital whose use-value is directly related to the production and burning of fossil fuels, such as mines, wells, power stations, refineries, and pipes) represents a constraining condition for the rapid emergence of a socioecological fix based on fixed capital formation in the lower-carbon energy sector.

2.2. Devaluation Forms

Fixed Capital Devaluation

Drawing on discussions of capitalist tendencies toward crises, and specifically from Marx's work on capital circulation in the *Grundrisse* and Volume 2 of *Capital*, Harvey provides a theory to understand the role of devaluation in capitalist development. Given that Marx uses the terms “depreciated,” “devalued,” “destroyed,” and “devalorized” inconsistently, and that their meanings tend to be further obscured when translated into English, Harvey restricts their use in the following way: while depreciation refers to the “changing monetary valuation of assets,” the term devaluation is reserved for “situations in which the socially necessary labor time embodied in material forms is lost without, necessarily, any destruction of the material form itself”. Therefore, “destruction relates to use values, depreciation to exchange values and devaluation to values” (Harvey, 1982:84).

Marx (1993:403) defines devalorization (*Entwertung*) as an integral moment in the process of valorization, which forces the sale of products in the market. Therefore, he associates valorization, the objectification of human labor during the production process, with a momentary interruption, a virtual devaluation given the need to realize commodities’ value in the market (Marx, 1993:621). According to Harvey (1982:85), the risk of this process being more permanently interrupted, which would produce real devaluation, is related to different barriers that can emerge in the circulation process, such as failure to find a purchaser, inventories that build up, and problems to deliver.

Devaluation of capital can take different “tangible forms,” such as the devaluation of commodities (e.g., overproduction), money (e.g. inflation), and labor power (e.g. unemployment or underemployment) (Harvey, 1982:86). The devaluation of fixed capital includes machinery and infrastructures such as power plants, refineries, oil and gas wells and pipelines, and coal mines. Fixed capital represents a produced production force already sold on the market (Harvey, 1982:224). Therefore, the exchange-value of fixed capital was already realized, so there is not risk of devalorization in the market. However, devalorization of fixed capital occurs as part of the routine process through which it "distributes" value and loses use value, i.e. its capacity to distribute value over the commodities produced with its use, in a rate dependent upon its durability (Marx, 1992b:238; Smith, 2008:168). However, as long as it is still useful and does not need replacement, some value remains fixed in it.

Harvey (1982:205) argues that fixed capital should not be understood as "a thing but as a process of the circulation of capital". From this perspective, the value of fixed capital is not inherent to its material form but dependent upon its usability in the production process. Therefore, fixed capital becomes devalued to the extent that it is not used in production and does not transmit its objectified value (Marx, 1993:744). This devaluation always involves a premature shutdown because it occurs before the expected lifetime or usability of fixed capital. Fixed capital devaluation is commonly caused by material deterioration, which can occur for several reasons, such as excessive or incorrect use (Marx, 1992a:528). In turn, fixed capital devaluation can produce material deterioration given a lack of use and maintenance. Another especially important type of devaluation is created by what Marx coined "moral wear and tear."

Moral Wear and Tear: Progressive and Periodic Devaluation

Moral wear and tear[1] corresponds to a type of devaluation in which fixed capital stops being used in production because of market and technological competition. Marx employs the term "moral" (*moralische*, i.e., human or social) to contrast devaluation caused by these types of competition with devaluation caused by material depletion. In moral wear and tear, the price of some forms of fixed capital fell following the introduction of cheaper or more advanced infrastructure and

[1] The original concept corresponds to *moralische Verschleiß* (Marx 1979:426), which, according to Smith (2017:14), has been "generally but erroneously translated as 'moral depreciation.'"

machinery (Marx, 1992a:528). This perspective influenced Schumpeter's understanding of creative destruction, in which capitalists are compelled to innovate and thus "destruct" (or at least devalue) past innovations. Smith (2017) names this ceaseless process of technological obsolescence "progressive devaluation". The different "tangible forms" (Harvey, 1982:86) of capital devaluation interlock in this process. For example, the devaluation of fixed capital can devalue labor not needed any more, and the devaluation of commodities can devalue fixed capital not used any more in their production.

Another important distinction in Marx's theory of fixed capital devaluation is the devaluation of individual versus general capital. Individual capital is devalued if in its exchange on the market it "experiences a depreciation for whatever reason, i.e. if it is sold at a price below its value" (Smith, 2017:10). However, these losses are commonly outweighed by "appreciation of some other capital" (ibid.). For example, progressive devaluation produces transitional periods of monopolistic gains with exceptional profits for innovators and owners of new machinery, and losses for producers and owners of devalued ones. Devaluation of individual and general capital are related to the cyclical processes of differentiation and equalization. While technological competition creates a tendency towards differentiation in the levels and conditions of production, it is normally followed by a process of equalization in which innovations are widespread within and among sectors, equalizing the rates of profit (Smith, 2008:155). Given that this process commonly leads to a gradual fall of the general rate of profit, progressive devaluation finally creates a general devaluation of capital "when the general capital either of a branch, or of a region of the world economy experiences a general and absolute destruction or loss of value" (Smith, 2017:10).

According to Smith (2017), moral wear and tear occurs as a result of not only progressive but also of "periodic" devaluations, which take place during economic crises. Periodic devaluations can be particularly violent and sudden and can affect different industries and regions at the same time, causing general devaluations of capital. Fixed capital is left temporarily or permanently idle during economic crises, many of which are in turn the result of progressive devaluation of capital and overproduction associated with the generalization of falling rates of profits.

As Harvey (1982:xxvii) describes, massive processes of fixed capital devaluation have occurred in the past as an intrinsic aspect of capitalist development. Indeed, he describes as "astonishing" the ability of capitalism to "organize and orchestrate gigantic devaluations of capital worldwide without, up until now, crashing the whole system". However, he also argues that "devaluation, arising for whatever reason, is always particular to a place, is always location specific" (Harvey, 1982:387) and that location is defined in large part by the anarchic forces of competition (Harvey, 1982:826). Similarly, Smith (2017:10) notes that progressive devaluation affects certain branches of capital randomly. According to Harvey (1982:329), only wars have played a key role in resolving capitalist crises by devaluing (and destroying) fixed capital through a more centralized and planned process and outcome, "a splendid and immediate means of devaluation through destruction". From this perspective, despite devaluation being an intrinsic aspect of capitalist development, a general and global devaluation of fixed fossil fuel capital, driven by profit and able to devalue a still operative, economic, and geographically dispersed network of fixed capital, represents an enormous challenge.

Moral Devaluation

The notion of moral wear and tear emphasizes the rules of economic and technological competition in creating devaluation. However, this is not a mechanical process. Moral wear and tear can be resisted and accelerated by different actors. For example, to delay devaluation, capitalists tend to accelerate the rate of use of fixed capital and expand its operative time, also expanding the working day (Marx, 1992a:528–530). Moreover, nation states have historically regulated "the pace of technological change" (Harvey, 1982:221) by, for example, providing subsidies and bailout schemes. The interactions among the logics of moral wear and tear and broader social aspects of devaluation can be captured by using the notion of "moral devaluation," i.e. the ensemble of economic and extraeconomic devaluation forces as well as modes of regulating the devaluation of fossil fuels, in the sense of private and public practices, rules, and institutions that govern how fixed fossil fuel capital loses value.

A useful way of emphasizing the extraeconomic dimensions of fixed capital devaluation is by engaging with the notion of socioecological fix. This notion is based on Harvey's (1982) view on the role of fixed capital formation in "spatial fixes" that temporarily resolves the need of over-accumulated capital to circulate, therefore preventing devaluation of capital. Critical environmental scholars have broadened Harvey's theory by incorporating the role of nature-society reconfigurations and political and cultural factors in the production of spatial fixes (Ekers and Prudham, 2015, 2017, 2018). By emphasizing the metabolic character of fixed capital, the notion of socioecological fix recognizes the role of specific natures in fixed capital formation, something that has been criticized as a latent aspect in Marx and Harvey theories (Ekers and Prudham, 2018:24). This is important for the moral devaluation of fossil fuels, because it highlights the need to distinguish how different fossil fuels (as energy resources) and fixed fossil fuel capital (as produced form of nature) participate in devaluation. Moreover, rather than resolving capitalist contradictions, socioecological fixes only temporarily alleviate some capitalist crises. Therefore, despite the devaluation of fixed fossil fuel capital being a necessary dimension of a possible socioecological fix to the climate crisis, it would not alter the capitalist law of value based on the exploitation of labor and nature (Smith, 2008) and would be prone to new socioecological crises.

The notion of socioecological fix has been used to study reconfigurations of nature-society relations to address the climate crisis. Recent research has analyzed, for example, the possibilities of renewable energies as socioecological fixes to temporarily resolve the climate and entangled crisis of capitalism (McCarthy, 2015), the limits that specific institutional and geographical conditions pose for these types of fixes (Spivey, 2020), and the risk of these fixes enhancing other environmental contradictions, such as the one caused by metal mining industries needed for electrification (Furnaro 2020). Despite an emphasis by this scholarship on the roles of fixed capital formation distributing value to facilitate circulation and accumulation as well as absorbing surplus value to prevent devaluation crises, different authors have also recognized the withdrawal of capital from the built environment as a condition for a capital switch away from the fossil fuel economy (Ekers and Prudham, 2018; McCarthy, 2015). More analysis, however, is needed to understand the role that the devaluation of fixed fossil fuel capital plays in that condition.

Drawing on the notion of moral devaluation and using examples provided by the academic and grey literature, the following sections illustrate different devaluation forces and regulatory devaluation mechanisms. The goal is to delineate some of the main logics through which the devaluation of fossil fuels is currently promoted, resisted, and regulated as well as to understand how fixed capital devaluation is limiting the possibility of lower-carbon energies to support a socioecological fix.

2.3. Devaluation Forces

Market Forces

Currently, coal is the only fossil fuel experiencing clear signs of progressive devaluation. This is related to the cheapening of renewable energy technologies, combined cycle gas, and unconventional techniques of oil and gas extraction (IEA, 2020b). The US has led the increase in the number of coal plant retirements since 2005 (Shearer et al., 2019). Examples of progressive devaluation within the coal industry have been widely documented in the past, with central Appalachia in the 1960s and South Wales in the 1980s serving as emblematic cases (Smith, 2015). While these cases were related to the general devaluation of capital in specific regions after, among other causes, production of cheaper coal elsewhere, clearer signs of general devaluation affecting the whole industry are observed today. However, in the case of other hydrocarbons, especially natural gas, they remain under most scenarios “a multi-trillion-dollar market for decades” (Barbosa et al., 2020:2), and therefore clear signs of general devaluation are still yet to be seen.

Critical energy scholars have argued that important obstacles to a progressive devaluation of fossil fuels have to do with some of their inherent properties, which make their use value more appropriate to economic growth than renewable energies (Malm, 2016; McCarthy, 2015). Among these advantages are being divisible, transportable, easily appropriated by individual firms, and detached from weather cycles. Moreover, the fact that the fuel for technologies such as solar and wind is free for the taking makes their exchange-value dependent on fixed capital used for capturing, converting, storing, and distributing energy, and not on energy resources extraction. Therefore, prices tend to decline when technologies develop, something advantageous in terms of progressive devaluation but not necessarily for capitalist growth (Malm, 2016:340). However, this obstacle can also be defied by price guarantees, long-term contracts, economies of scale, rent capture from investors, and accumulation in the production of minerals needed for electrification and batteries, among other possible mechanisms (see, for example, Baker, 2021; Harrison, 2020).

Another obstacle to a progressive devaluation of fixed fossil fuel capital is the constant investment in technological development by fossil fuel companies, which results in the lowering of production costs. This is evidenced by the advancement of unconventional extraction techniques and the extension of the productive life of mature and abandoned mines and fields (Finch and Acha, 2008). Technological innovation also gives new uses to devalued energy resources, such as producing plastic from coal, resisting fixed capital devaluation through repurposing. The fact that cheaper renewable energies do not always represent a market devaluation force is seen when fossil fuel companies incorporate these technologies in their production processes or invest in them elsewhere as a way of declining and offsetting their carbon emissions, respectively, therefore legitimizing continuous fossil fuel production. These technological responses are part of what Carton (2019:765) describes as the political economy of delay, “a constellation of economic, political, cultural and everyday practices that in numerous ways serve to postpone the necessary devaluation of fixed fossil fuel capital”.

Other relevant examples of economic devaluation forces (see Table 1 for a summary) take place during economic crises. These periodic forms of devaluation include the global contraction of coal, oil, and gas production with the decline in demand during the economic depression of the 1930s, the financial crisis of the late 2000s, and during the COVID-19 pandemic (IEA, 2020b). Given that the coal industry was already facing progressive devaluation, the shock in demand during the pandemic is having a devastating effect for coal companies, and a wave of bankruptcies can be observed in several countries, while lower costs renewable energies, particularly solar PV, are growing in different recovery scenarios (IEA, 2020b; IEEFA, 2020). Periodic devaluations during crises are normally contained by regulatory responses. For example, since the financial crisis, so-called unconventional monetary policies, such as negative interest rates and quantitative easing, have disproportionally benefited fossil fuel energy industries (Matikainen et al., 2017; van Lerven, 2020), offering a bailout during periodic devaluation for companies that, in many cases, were already affected by progressive forms of devaluation.

Table 3. Devaluation Forces – Examples

Market forces	**Political forces**	**Biophysical forces**
• **Progressive devaluation (e.g. cheaper technologies or alternative fuels)** • **Periodic devaluation (e.g. crises of overproduction, price volatility)**	• Socioecological conflicts (e.g. environmental regulations, legal claims, consumer boycotts, divestment campaigns) • Distributive conflicts (e.g. blockades by workers and communities)	• Climate disasters (e.g. hurricanes, droughts, winter storms) • Resource exhaustion (e.g. depletion of fields and mines, water shortages)

Drops in prices related to the volatility of the energy markets also produce periodic forms of devaluation for less competitive operations. For some of them, the high costs of reactivation can cause the permanent devaluation of fixed capital (Corts, 2008). In other cases, however, the high costs of decommissioning and cleanup incentivize operators of idle coal mines, oil fields, and power plants to wait for chances to restart the project in the future (Muehlenbachs, 2015), weakening the ability of periodic devaluation to ensure a more permanent devaluation of fixed capital. Moreover, decarbonization by periodic devaluation associated with a drop in prices can be outweighed by the production increase in cheaper operations in regions with less environmental regulation, by the increase in consumption, and by the relative depreciation of renewable energy technologies.

Political Forces

Many relevant devaluation forces affecting fixed fossil fuel capital are beyond the logics of progressive and periodic devaluation. This is the case of coercive pressures that provoke the devaluation, and in some cases the destruction of fixed capital, described by Mitchell (2011:39) as sabotage, or the "ability to interrupt, restrict or slow down the supply of energy". Some sabotage practices have to do with social relations internal to the industry, such as blockages by coal workers due to disputes over working conditions. Sabotage has also been created by capitalists, in some cases violently and destructively, to avoid depreciation created by overproduction (Huber, 2011). In this case, individual devaluation of capital is strategically provoked to avoid a general devaluation affecting the whole industry. Other political forces that have created devaluation of fossil fuels through sabotage includes conflicts with local communities for the distribution of revenues (Perreault 2006), geopolitical conflicts (Bridge and Le Billon, 2013), and theft (Watts, 2007). These examples, despite being incapable of causing a general and global devaluation of fixed fossil fuel capital, can create periodic and permanent devaluation of fixed capital in specific firms and regions.

Workers employed in fossil fuel industries have also represented an important force resisting devaluation of fixed capital given the concomitant devaluation of labor, which is particularly difficult to avoid in capital-intensive industries (Harvey, 1982:86). Not only coercive (e.g. bribery and corruption) but also more licit practices (e.g. regulated lobbying) have been used by firms, many times in alliance with workers, to resist the devaluation of fixed capital in cases of progressive devaluation. Examples have been widely described by the energy transition literature (Geels, 2014; Oei et al., 2020; Unruh, 2000). Resource nationalism and cultural attachment to fossil fuel industries also represent important sources of resistance to the devaluation of fixed capital in countries such as Poland and the United States (Kuchler and Bridge, 2018). More recently, the rise in right-wing populism has emerged as another political force resisting the devaluation of fossil fuels, principally for ideological reasons, such as opposing decarbonization policies for being seen as cosmopolitan elite agendas (Lockwood, 2018).

Energy-intensive industries have also resisted the devaluation of fossil fuels. For example, in the Ruhr area in Germany, the downstream steel industry participated in powerful networks of firms, workers, and politicians to resist the progressive devaluation affecting the coal industry since the late 1950s (Oei et al., 2020). In Chile, the copper mining industry resisted until very recently the incorporation of cheaper contracts with the renewable energy sector in part because power purchase agreements with incumbent producers was perceived as more secure in terms of supply than contracts with newer renewable energy providers (Furnaro, 2020). This embeddedness between fixed capital devaluation in fossil fuel and energy-intensive industries, associated with the central role of fossil fuels in ensuring cheap and continuous industrial production, incites resistance to the devaluation of fossil fuels as energy commodities, and with it, of fixed fossil fuel capital.

Conflicts centered around the environmental and health effects produced by fossil fuels represent another important political devaluation force, which has produced devaluation not only through sabotage, such as occupations that shut down investments (Brock and Dunlap, 2018), but also through litigation that forces the premature closure of operations (McDuie-Ra and Kikon, 2016), and environmental regulations that make them more expensive (Linn and McCormack, 2019). Strong environmental regulations have great potential to produce a general rather than individual devaluation in subjected countries or regions. However, place-specific environmental regulations are also susceptible to carbon leakages, i.e. an increase or offset in emissions related to GHG emission-intensive activities being relocated in regions with lower regulations, which limit their potential to create a global devaluation of fossil fuels.

Another way through which socioecological conflicts have caused fossil fuel devaluation is with a drop in demand that blocks the realization of fossil fuel energies in the market. This can be based on organized boycott campaigns, demand-side regulations, or cultural changes in consumption practices (Kennedy, 2017). In these cases, the process of “devalorization” (Marx, 1993:403) of fossil fuel energies as commodities is made more permanent, effectively creating fixed capital devaluation. However, estimations of when a peak demand for hydrocarbons may occur, particularly oil and gas, are still ambiguous (IEA, 2018).

A more recent devaluation tool associated with ecological claims is divestment pressures. Divestment campaigns, which started in the 2010s, promote the full or partial removal in key investors’ portfolios of assets exposed to fossil fuels (Knuth, 2017), therefore generating devaluation of fossil fuels through devaluation of financial capital. Decisions to divest are increasingly based not on ethical reasons but on the need to prevent higher costs for investors of an expected devaluation (Bos and Gupta, 2018). In this context, critics suggest that rather than a strong political devaluation force, divestment decisions represent risk management practices that involve the selling of assets to less environmentally committed investors instead of ensuring the effective devaluation of fossil fuels (Wisor, 2014).

Biophysical Forces

Biophysical devaluation forces correspond to more-than-human natural constraints that create devaluation of fixed fossil fuel capital. Although some of these forces tend to be beyond direct social control, they are shaped and, in some cases, caused, by social conditions, and therefore represent a moral devaluation force. This is evident in the devaluation of fixed capital caused by the effects of climate change, as was the case of offshore oil platforms destroyed in the Gulf of Mexico by Hurricanes Rita and Katrina in 2005, or more recently, natural gas pipelines bursting, coal power stations knocked offline, and power lines damaged due to the 2021 winter storm in Texas. The drop in demand for coal and gas during milder winters represents another way by which the effects of climate change are devaluing fixed fossil fuel capital. In this case, an ecological constraint causes devaluation of fixed capital not through destruction but through a drop in demand. However, rising energy demand for air conditioning and refrigeration equipment can offset this seasonal pattern on a global scale (IEA, 2020c).

Resource exhaustion is another socially mediated biophysical force that is devaluing fixed fossil fuel capital. This is particularly important in relation to water, whose shortage is of rising concern for the production of all types of fossil fuels, which are among the most water-intensive industries (Sohns et al., 2016). In the case of fossil fuel reserves, given that they are still plentiful, resource exhaustion has forced the shutdown of operations in specific fields and mines, devaluing individual capital without affecting the global industry (Heede and Oreskes, 2016). In fact, it is resource abundance rather than scarcity that has caused greater devaluation of fixed capital, associated with overproduction (Huber, 2011) and the climate crisis (Mitchell, 2011).

About the role of climate change as a biophysical devaluation force, Sayre (2010:104) observes that "directly or indirectly, global warming is going to devalue our current built environment anyway," which includes the fossil fuel energy landscape. In this case, the production of fossil fuel energy, as a metabolic process, operates as an indirect devaluation force, which produces the material depletion of its own fixed capital through the mediation of environmental hazards. This rising risk of material depletion has promoted the creation of regulatory responses that try to cope with losses for firms and investors by measuring and governing the possible costs of devaluation, such as new insurance schemes and corporate risk disclosure. Following Christophers (2017), these climate risk management practices are enacted under the assumption that they can encourage "systematic" financial stability, or in other words, avoid an abrupt and general devaluation of financial capital caused by the climate crisis, which involves not only the biophysical forces but also private and public practices that promote decarbonization through devaluation.

The following section analyses different mechanisms through which the devaluation of fossil fuels has been regulated in recent decades, most of which operate through the mediation of market competition rather than through direct devaluation pressures.

2.4. Regulating Devaluation

Market Mediation

As Table 2 summarizes, most of the regulatory mechanisms that have contributed to the moral devaluation of fossil fuels since the 1990s have used the mediation of the market and have focused on the demand side of fossil fuel energy production (i.e. power production and fossil fuel burning rather than extraction and refining). These mechanisms correspond to a combination of command-and-control and market-based approaches that foment renewable energies and try to destabilize fossil fuel energy systems. More direct modes of regulating devaluation that ensure an exit date for fossil fuel extraction and burning have been scarce. Therefore, the recent boom of binding coal phase-out agendas constitutes a new moment in decarbonization policies.

Table 4. Fossil Fuel Devaluation—Regulatory Mechanisms

Market mediation		**Direct devaluation**
Command-and-control	**Market-based**	
• Renewable energies support (e.g. research and development, feed-in-tariffs, auctions) • Fossil fuel restrictions (e.g. pollution and emissions standards, elimination of subsidies)	• Carbon pricing (e.g. ETS, carbon taxes)	• Bans and moratoriums (e.g. closing mandates, no longer issuing permits, emissions caps, compensation payments) • Phase-out laws

Market-based decarbonization policies, such as emissions trading systems (ETS) and carbon taxes, represent forms of carbon pricing that reduce the competitiveness of fossil fuel energies by making its production more expensive, also reducing the demand for extraction. However, these regulations have been described as weak, based on timid tax rates or, in the case of ETS, an oversupply of permits that keeps carbon prices low (Bumpus and Liverman, 2008). In this context, carbon pricing has been characterized as "market environmentalism," compatible with business-as-usual capitalist growth (Carton, 2017). In the case of the EU Emissions Trading System (EU ETS), the pricing system was strengthened only after political pressures forced EU officials to introduce the market stability reserve in 2015 and further negotiations in 2017 reduced the volume of allowances in the market (Schäfer, 2019), showing the relevance of political work in making carbon pricing a more powerful devaluation tool.

According to Rentier et al. (2019), a high carbon tax implemented in the UK in 2013 in combination with the country's liberal market economy played a key role in rapidly phasing out coal power plants with the depreciation of coal in relation to gas power. In contrast, in coordinated market economies in Germany, Spain, and Poland, public ownership, high subsidies, and labor protections have slowed down the progressive devaluation of coal. However, market-based devaluation mechanisms that are not accompanied by tools to restrict production do not ensure a continuous decarbonization process. In the UK, for example, lower prices made utilities more interested in using coal during the periods of 1999–2006 and 2010–2012 (Geels, 2014), causing two coal "revivals" (Rentier et al., 2019:626). Similarly, Carton (2017) describes how after the implementation of the EU ETS, installation priorities were reordered, bringing cheaper gas-fired capacity ahead of coal. This, however, can be easily reversed when market conditions change, as was the case after 2011. In addition, despite the introduction of the market stability reserve, new concerns have been expressed about the ability of the EU ETS to deal with a new surplus of allowances associated with coal plant closures, which could again lower prices (Carbon Market Watch, 2019).

Considering the environmental impacts of fossil fuel industries in decline is particularly important when devaluation is driven by market forces or mediated by market competition and when environmental regulations are weak. Companies that produce fossil fuel energies and that are facing economic pressures, especially smaller ones, tend to be less efficient and accountable, resulting in a disproportional share of environmental problems (Boomhower, 2019). Therefore, although market mechanisms can promote a rapid devaluation of fossil fuels, without additional regulations, their ability to ensure a continuous decarbonization process and a correct management of environmental liabilities can be limited.

Command-and-Control

Command-and-control policies implemented in the last two decades to promote renewable energies have been an effective driver of the progressive devaluation of fossil fuels, particularly coal. This is the case of public funding in research and development, which has promoted progressive devaluation of fossil fuels through improving the technological competitiveness of lower-carbon energies (Mazzucato, 2013). Similarly, feed-in tariff schemes, renewable energy mandates, and ad-hoc auctions, promote the market access of renewable energies. However, these approaches do not resolve the problem of renewable energy investments expanding energy production rather than replacing fossil fuels. As Malm (2016:351) highlights, renewable energy "adds another slice to an ever-growing energy pie; merely building the flow infrastructure will accomplish a tenth of a transition, unless there is a simultaneous 'direct suppression of fossil-fuel use'". This tendency was confirmed by York (2012), who showed that, from 1960 to 2009, 1 kilowatt-hour of non-fossil fuel-based electricity replaced, on average, only 0.1 kilowatt-hours of fossil electricity.

Power overcapacity is related to the energy security approach that has guided the implementation of several command-and-control policies to promote renewable energies (Scoones et al., 2015).

Given the importance of national states in ensuring abundant, reliable, and cheap energy for capitalist growth, it is not surprising that carbon-mitigation policies have favored overcapacity rather than risking provision gaps. More recently, public efforts to promote lower-carbon energies have been successfully framed as industrial policies to stimulate demand for investment and labor (McCarthy, 2015). Under this logic, renewable energies involve the risk of becoming more important in the formation of fixed capital and spatial fixes, rather than as socioecological fixes able to produce a rapid devaluation of fossil fuels.

Stricter environmental regulations and the elimination of subsidies represent more effective command-and-control policies to devalue fixed fossil fuel capital, which are also important precursors for the recent boom in phase-out agendas (Rentier et al., 2019). For example, the European Commission adopted in 2017 new pollution standards for large combustion plants. Given the substantial investment required to meet the standards, this policy represented a de facto phase-out instrument for many operators (Galgóczi, 2019:16). Similarly, in 2016, Belgium became the first coal-burning member of the EU to phase out coal, a process that was not based on a government phase-out plan, but rather on the closure of aging plants affected by environmental regulations (Europe Beyond Coal, 2020).

Investing in retrofitting technologies is a common form of resisting fixed capital devaluation caused by environmental regulations. This is the case of carbon capture systems and co-firing of biomass and coal. In the case of abatement technologies, these are still too expensive to be a widely extended solution, and their long-term ecological outcomes are unclear (Carton et al., 2020). In Europe, the effects of coal-to-biomass conversion have been especially concerning for increasing emissions associated with deforestation, wood burning, and imports of wood

(Carton, 2016). Therefore, the capacity of these responses to repurpose fixed fossil fuel capital and give it a new life as lower-carbon (or even "negative carbon") fixed capital, rather than to simply delay fixed capital devaluation, is far from clear.

The elimination of subsidies is another important command-and-control policy that promotes devaluation. In the 2009 Pittsburgh Summit, the G20 leaders agreed to gradually eliminate fossil fuel subsidies, including some exceptions such as subsidies beneficial for low-income households or that promote the development of abatement technologies. However, a recent report on fossil fuel subsidies, which also includes indirect subsidies such as underpaid environmental costs, shows that they remain high around the world (Coady et al., 2019). Coal represents the largest source of subsidies globally, followed by petroleum, natural gas, and electricity output. This is a fundamental constraint for a rapid decarbonization because subsidies restrain the capacities of renewable energies to devaluate fixed fossil fuel capital through progressive devaluation.

Direct Devaluation: Phase Out Plans

Since the mid-2010s, several governments have announced coal phase-out plans and agendas that ensure the end of coal extraction and power production. The first coal phase-out plan was announced by the Canadian province of Ontario in 2003. The government committed to phasing out coal-fired generation by 2014, a goal that was completed in 2013 (Sovacool, 2016). In 2015, the UK became the first country to announce a coal phase-out agenda, which established the end of coal power production by 2024. The German coal phase-out program announced in 2019 is the most ambitious in terms of size (40 GW), although its schedule is not aligned with the Paris Agreement. Targeting coal is strategic because it is the most carbon-intensive fuel. However, rather than mere decarbonization strategies, devaluation of coal is a common condition for coal exit plans, rather than the other way around (cf. Europe Beyond Coal, 2020; Oei and von Hirschhausen, 2016), and therefore coal phase-out plans regulate an ongoing devaluation.

Normally, coal phase out plans include a combination of tools for the “paying-out” (e.g. financial compensations), “pricing-out” (e.g. carbon taxes), and “pushing-out” (e.g. bans) of fixed capital. In Germany, the plan is based on a paying-out model that provides financial compensations to lignite companies, regions, and workers as well as to industrial energy consumers. In France, the government announced in 2016 a plan to phase out coal by 2023 through a pricing-out model based on a strong carbon tax and emissions cap. As a more direct devaluation mechanism, bans have created less political support and have been less implemented. Moreover, this pushing-out mechanism can be costly in terms of legal claims by companies forced to prematurely shutdown fixed capital (Micklinghoff, 2013). To prevent this, the Finnish government enacted a ban in 2019 that prohibited the use of coal in power generation, but only after mid-2029 (Europe Beyond Coal, 2020). In response to critiques against this timeframe, the government created a €90 million fund to compensate companies ending the use of coal before this date, incorporating a paying-out component in the pushing-out plan.

Despite phase-out plans involving a final devaluation of coal, strategies to postpone devaluation through these plans are common. For example, many phase-out plans use an average lifetime based on records of decommissioned power plants to define phase-out agendas rather than company sheets and market expectations (Farfan and Breyer, 2017). Because coal power plants are facing progressive devaluation, considering an average lifetime of fixed capital overestimates its life expectancy. This is evident in settings wherein progressive devaluation in shutting down power plants before the time defined by phase-out agendas (Europe Beyond Coal, 2020). Therefore, phase-out approaches that attach a fixed value on fixed fossil fuel capital, based on an average lifetime or other metrics, rather than one dependent on potential productive uses (Marx, 1993:744), contribute to delaying devaluation. This way of accounting the value of fixed capital can also overestimate compensation payments by paying-out schemes. This is the case in the Netherlands, where the coal phase-out plan announced in 2017 uses average lifetime of power stations to calculate compensation payments for utilities (Europe Beyond Coal, 2020).

Keeping plants on stand-by is another approach used in phase-out agreements to delay devaluation and transfer devaluation costs away from fossil fuel companies. For example, in the German case, the capacity reserve system created in 2015 to ensure security of supply will be used to allow some operators to receive compensations for keeping plants on hold for four years (BMWi 2019). After this period, they must shut down permanently. In Germany, this approach extends the lifetime of fixed capital despite power overcapacity and subsidizes plants that would otherwise have to shut down given progressive devaluation. Moreover, although phase-out plans in Europe are commonly presented as environmental policies, most of them rely on an increase in investments in fixed capital for the use of natural gas (Galgóczi, 2019). Increasing reliance on natural gas is related to, among other causes, its role in facilitating system reliability as well as European-Russian natural gas trade and geopolitical relations (Gustafson, 2020). The central role of natural gas in phase-out plans creates a new carbon lock-in, therefore promoting the final devaluation of coal while postponing the devaluation of natural gas.

Finally, an important problem for phase-out plans is a possible rush to extract and burn fossil fuels before it is too late. The tendency to increase production when devaluation is expected, also called a "green paradox" (Jensen et al., 2015), is related to the need to "distribute" the value embodied in fixed capital in the shorter term in order to lessen the costs of devaluation. Therefore, a key challenge that the rules of fixed capital devaluation pose for phase-out plans in the coal, oil and gas sectors is how to accelerate the devaluation of fixed capital, while at the same time avoiding inefficient extraction and burning practices that would raise emissions (at least in the short term).

2.5. Conclusions

By putting into conversation Marx's theory of devaluation, critical energy studies, and the literature on the socioecological fix, this paper provided a vocabulary to analyze the challenges associated with the need to devalue fixed fossil fuel capital in order to "fix" the climate crisis by a capital switch towards cleaner energies. Although fixed capital formation in lower-carbon energies represents a necessary condition for a socioecological fix to the climate crisis (McCarthy, 2015), its contribution in such a fix would only be partial if not accompanied by effective devaluation of fixed fossil fuel capital, a process ruled by related but different logics. Moreover, fixed capital devaluation, driven by any reason, is normally associated with unemployment, high costs for the state, and massive industrial waste (Harvey, 1982). Therefore, devaluation of fossil fuels has to be understood as a multidimensional challenge, whose resistance can block the possibility of a socioecological fix to the current climate crisis and whose emergence can deepen existing, as well as produce new, socioecological burdens.

Empirical investigation is required to better understand how the devaluation of fossil fuels occurs in specific places and according to different types of energy resources, technologies, and infrastructures. However, paying attention to the devaluation of fossil fuels in general is needed as well, not only given that real decarbonization involves them altogether, but also because important devaluation logics are shared by all types of fixed fossil fuel capital, and decarbonization by devaluation of one type should not hide emissions from another type. On this basis, the moral devaluation framework presented in the paper can be useful in informing future empirical work on the phase-out of fossil fuels as “variegated and combined” processes (Bridge and Gailing, 2020) in at least four ways.

First, by emphasizing the constraining condition that devaluation implies for a genuine and rapid socioecological fix to the climate crisis, this framework is useful to analyze the limits of decarbonization approaches centered on fixed capital formation in the lower-carbon energy sector but that are relatively silent about how to address the devaluation challenge, such as Green New Deal plans that do not involve strict phase-out agendas. Rather than assuming new investments in the lower-carbon economy as the main driver for decarbonization, the notion of moral devaluation forces us to examine the multiple ways through which resistance to devaluation take place, despite the use of fossil fuels not being an economically (e.g. given progressive devaluation) or even energetically (e.g. given power overcapacity) sound decision.

Second, by highlighting multiple interactions among economic and extraeconomic devaluation forces and modes of regulating devaluation, this framework can be used to assess phase-out plans as more than environmentally motivated agendas. This is evident when examining the boom in coal phase-out plans in Europe, especially those strongly based on paying-out mechanisms, from the perspective of the ongoing progressive devaluation of coal, which has made some of these plans economically desirable in the first place. In turn, environmental pressures have increasingly been internalized by the market, and the devaluation of coal cannot be understood as solely economically driven without considering how climate regulations have impacted energy markets. In this context, empirical work is needed to analyze to what degree specific phase-out plans truly mitigate the climate emergency by accelerating devaluation, or rather minimize losses of an ongoing and delayed devaluation. Moreover, the emphasis on different ways to not only strategically promote but also defer devaluation also calls for greater attention to private and public strategies to resist devaluation during and through phase-out processes.

Third, by providing an active concept of devaluation as a political process that can take different shapes, rather than as an undifferentiated mere result of technological replacement, this moral devaluation framework promotes the analysis of variegated forms of decarbonization by devaluation. Strong market-based mechanisms used to tax and cap emissions have had great potential to rapidly devalue coal. However, when these are not complemented by regulations that ensure an exit date, the risks of coal "revivals" (Rentier et al., 2019) under changing market conditions are concerning. Therefore, market pressures alone, either driven by policy or market competition, are incapable of ensuring a continuous and in-time decarbonization process, making direct devaluation mechanisms necessary. Research is required to appreciate how situated phase-out mechanisms operate and interact as well as their effects in terms of decarbonization by devaluation in different regions and at different scales.

Fourth, by making visible some of the economic, social, and environmental effects associated with the devaluation of fossil fuels, this framework urges us to empirically follow how these effects are created, transferred, and disproportionally distributed. This includes analyzing: new socioecological outcomes created by the devaluation of fossil fuels, such as environmental damage around idle and decommissioned sites of fossil fuel production; how costs of devaluation are defined, accounted, and hidden; legal and financial strategies to make exit subsidies available and unavailable, capture public funds, transfer devaluation costs to taxpayers and ratepayers, and responses from below; socioecological outcomes associated with infrastructural repurposing and the (re)valuation of former fixed fossil fuel capital; new forms of uneven development created by the phase-out of fossil fuels and uneven forms of experiencing devaluation within and between countries in the global North and South.

Finally, while investors and companies have made visible some of the economic risks of devaluation (popularized under the "stranded assets" buzzword) and created several risk management practices to reduce and transfer possible losses, critical energy scholars need to name, visualize, and follow the uneven and everyday socioecological consequences of different forms of resisting, promoting, and regulating the devaluation of fossil fuels. This moral devaluation framework seeks to contribute to this goal by providing conceptual tools that emphasize some of the multidimensional aspects of fixed capital devaluation and its connections with broader capitalist logics. By highlighting that the value of fossil fuels as commodities and fixed capital is not inherent to their material form but dependent upon their realization in the market and their usability in production, respectively, Marx's devaluation theory is helpful because it prevents a fetishist understanding of fossil fuels as inherently negative "things" (Harvey, 1982:205) and force us to look at the productive process and its politics as crucial terrains to assess the possibilities for a real, rapid, and more socially just decarbonization process.

CHAPTER 3. REGULATING DEVALUATION IN THE GERMAN COAL PHASE-OUT

3.1. Introduction

Though Germany is often considered a leader in green energy for its strong commitment to the development of renewable energies, the country remains a top lignite extractor and coal power producer (IEA, 2022a). However, a coal exit plan enacted in 2020 outlines the end of coal extraction and burning by 2038, at the latest. This plan is based on generous compensation to coal companies. Important modifications to this plan are expected, especially around the compensation amounts and target dates. In November 2021, the new government's coalition agreement stated 2030 as the phase-out deadline. An earlier deadline is also expected due to rising CO2 prices and a 2021 rebuke by the German Constitutional Court that will strengthen decarbonization policies.

This paper contributes to the political economy of energy transitions literature (Baker et al., 2014, Bridge and Gailing, 2020, Pearse, 2021) by highlighting the role of coal devaluation in the destabilization of incumbent energy regimes, something that has been understudied by social science energy transition scholarship. It draws on theories of capital devaluation (Harvey, 1982, Smith, 2017) and their application to fossil fuel industries (Carton, 2019, Furnaro, 2021) to frame the phase-out of fossil fuels as a specific political-economic process, distinct from the expansion of renewable energies. Theories of devaluation are put into conversation with a relational political-economic approach inspired by regulation theory to conceptualize historical trajectories of coal devaluation and its continuities with contemporary coal exit plans as well as mutually constitutive political-economic articulations in shaping coal exit plans.

Germany's coal exit plan continues the country's tradition of regulating the devaluation of coal (the novelty of a final date for coal notwithstanding). The use of abundant compensation for coal companies to transfer devaluation costs to the public sector is a regulatory mechanism dating back to the coal crisis of 1957. Through this mechanism, the state has shielded coal companies from competition and slowed devaluation. In recent years, this tendency has been in tension with the forces of devaluation caused by decarbonization policies, creating the paradox of Germany's green reputation when it comes to renewables but a much dirtier one in relation to coal. The 2020 coal exit plan reproduces traditional methods of regulating devaluation due to the influence of the pro-coal lobby and its interpretation of the exit agreement as a process that was and should be purely politically (versus market) driven. However, in addition to being a politically motivated climate policy, Germany's coal exit plan is a response to a political-economic quandary in which the government needs to: (1) regulate the economic devaluation affecting the energy sector, especially the coal industry, and (2) address a double legitimation crisis associated with the devaluation of coal, which has galvanized both environmental critiques and far-right populist groups.

This study is based on 55 interviews conducted by the author between June 2019 and September 2021, with scholars, energy consultants, representatives from the coal industry, trade unions, policymakers, and politicians involved in the coal phase-out.[2] This paper also draws on the analysis of 17 interviews with members of the Coal Commission conducted by the Coal Exit research group at the Technische Universität Berlin and an extensive review of policy

[2] A snowball sample approach was followed, through which different stakeholders related to the coal phase-out process were contacted. The interviews were semi-structured and focused on the conditions, timing, procedures, and outcomes of the Coal Commission and Coal Exit Law.

documents, research publications, company reports, and news articles. The identities of the interviewees have been anonymized. The remainder of this paper is organized as follows: the next section outlines the political-economic theory framing this study, while Section 3 provides a historical overview of the regulatory roots of the German coal exit plan. Section 4 examines the main political-economic drivers of the so-called coal exit compromise and Section 5 analyses how and why profuse compensation payments to coal companies emerged.

3.2. The political economy of phasing out coal

A relational political-economy of phase-out processes

Most political-economic research on energy transitions has focused on the development of renewable energies, leaving the phase-out of fossil fuels relatively understudied. However, with the recent decline in coal production and the introduction of coal exit plans in several countries, scholarly work is beginning to emerge on the destabilization of coal-intensive energy regimes through discursive, technological, market, regulatory, among other mechanisms (Brauers, Oei, and Walk, 2020, Leipprand and Flachsland, 2018). However, policy literature often uses a dualist interpretation of coal phase-outs as either policy- or market-driven (Rentier et al., 2019, Drake and York, 2021) though such a sharp distinction is rarely observed. For example, state policies have traditionally played an important role in making coal less competitive by subsidizing renewable energies or pricing carbon, creating subsequent market-driven effects (Lamperti et al., 2019).

On the other hand, energy transitions since the end of the twenty-first century have been predominantly promoted by state policies (in contrast to more technologically driven past transitions) (Kern and Markard, 2016). Moreover, social movements and campaigns are increasingly driving the phase-out of fossil fuels, foregrounding the outwardly political (versus economic) character of these transitions (Drake and York, 2021). To avoid overestimating the role of both state and market, we must consider how market signals of economic decline make divestment and phase-out plans more politically palatable, and how access to economic resources makes some anti-coal campaigns more successful than others (see, for example, Dierwechter, 2020).

A relational political economy approach influenced by regulation theory can help prevent a dualistic interpretation of phase-out processes. Founded in the late 1970s by French economists, the regulationist approach offers terminology to understand how capitalist economies reproduce themselves, despite inherent crisis tendencies (Lipietz, 1988, Jessop, 2003, Jessop and Sum, 2006). The theory distinguishes between 'regimes of accumulation' (RA) as 'a particular combination of production and consumption which can be reproduced over time despite conflictual tendencies', and 'modes of social regulation' (MSR), 'an institutional ensemble and complex of norms which can secure capitalist reproduction' (Jessop, 1988, p. 150). Central to this paper is the Polanyian relational understanding, shared by the regulationist approach, of the mutual embeddedness of political and economic processes. For example, political economists of energy influenced by the regulation approach understand political and economic drivers as mutually constitutive and entangled in energy systems in transformation (Bridge and Gailing, 2020, Gailing et al., 2020). From this perspective, the political (which includes governments and governance) and the economic (which includes production, distribution, and market relations) are not seen as a priori entities independent of each other – both are economically and politically active (cf. Jessop, 2001).

Given its roots in historical materialism, the regulationist tradition prioritizes analysis of geohistorically concrete social relations, normally through epochal periodization (Lipietz, 1988). However, phase-out processes are not only shaped by the logics of RA and MSR generally, but also by the contingencies of particular political struggles. Therefore, to study the phase-out of fossil fuels in specific contexts, we should also consider geohistorical conjectures. Influenced by Gramsci's (1971) attempt to address historical contingencies and difference, conjunctural analysis seeks to make sense of concrete social formations in relation to more general structural forces (Hall, 1986). Rather than compartmentalizing phase-out drivers into a binary, we can analyze how they are part of specific conjunctures.

Despite the regulation approach being employed to study the relationship between crises of capitalism and changes in energy and accumulation regimes (Huber, 2013), it has rarely been used in the study of energy transitions (Haas, 2019), especially of the phase-out of fossil fuels. Political economic theories of capital devaluation applied to the study of fossil fuels offer a useful analytical advance in this direction.

The moral devaluation of coal

Mitigating the climate crisis requires urgently reducing the production and burning of coal. Therefore, a 'devaluation' of fixed capital or, the loss in value of infrastructure like mines and coal-fired power stations before their productive lifetime is over, must occur. This challenge, also known as the risk of stranded assets, represents a barrier to on-time decarbonization because the energy sector (and others) resists the costs of fixed capital devaluation (Carton, 2019). These costs go beyond direct losses for capitalists and also include the concomitant devaluation of labor (unemployment) and nature (degraded post-fossil fuels environments) (Furnaro, 2021). However, devaluation is an intrinsic part of capitalism. Capitalist economies systematically create devaluation as a result of technological competition and economic crises (Harvey, 1982). Moreover, strategic devaluation of fixed capital, labor, and currencies are commonly used to offset devaluation affecting specific industries, regions, countries, or capital in general (Smith, 2017). In the case of fossil fuel companies, purposeful individual devaluation of fixed capital is common during crises of overproduction; it raises prices to prevent a general devaluation of the whole industry (Huber, 2011).

Drawing on theories of capitalist devaluation (Harvey, 1982, Smith, 2017), and particularly on the notion of 'moral wear and tear', the concept of a moral devaluation of fossil fuels emphasizes social drivers beyond material depletion (Furnaro, 2021). From this perspective, the sphere of production represents the locus where devaluation of fixed fossil fuel capital materializes, and market and technological competition represent important drivers, a process that Smith (2017) describes as 'progressive devaluation'. While periodic forms of devaluation occur during economic crises (whole regional or planetary economies), progressive devaluation affects individual capitals (specific firms or operations) or, in some cases, whole industries or sectors (Smith, 2017). Therefore, progressive devaluation is associated with the political economies of industrial upgrading (improving industrial production by replacing less efficient machines and practices (Streeck, 1997)) and 'exnovation' (divestment from certain technologies and production structures (David, 2018)).

Moral devaluation is not an economically determined process but rather a non-teleological dialectic between multiple structuring, contingent, economic, and more-than-economic forces in specific spatio-historical conjunctures. In other words, studying the moral devaluation of coal involves analyzing how economic forces of devaluation interact with political ones, which are related to environmental, distributive, geopolitical, among other relations and practices that lead to the shutdown, and in some cases destruction, of fixed fossil fuel capital. While political drivers include the direct use of force (Brock and Dunlap, 2018), they may also come in the form of litigation (McDuie-Ra and Kikon, 2016), environmental regulations (Linn and McCormack, 2019), boycott (Kennedy, 2017) and divestment campaigns (Knuth, 2017).

The regulation approach identifies changing modes of social regulation which respond to crises in the accumulation regime (Jessop, 2002). This is especially helpful in understanding crises of devaluation affecting the fossil fuel energy regime since public and private entities play a key role in regulating, and especially resisting, real and perceived forms of devaluation. The state plays a key role in these processes as enabler, stabilizer, and orchestrator of capital devaluation (Harvey, 1982). Policy tools to resist devaluation include bailout schemes, tax benefits, public acquisition of firms, and other direct and indirect subsidies (Rentier et al., 2019). Companies resist devaluation through work rationalization, vertical and horizontal integration, increases in outputs, and lobbying (Harvey, 1982). Carton (2019) calls these processes of resisting devaluation 'the political economy of delay', 'a constellation of economic, political, cultural and everyday practices in numerous ways serve to postpone the necessary devaluation of fixed fossil fuel capital' (765). However, governments and companies that resist the devaluation of coal may lose public confidence (Geels and Verhees, 2011, Sareen, 2019). Many governments face a double legitimation crisis: from anti-coal organizations and communities negatively impacted by coal production and from workers and communities that could be negatively affected by devaluation.

Methods of regulating devaluation vary across different national and regional political economies. While more coordinated economies tend towards slower devaluation processes, appeased through state support and the resistance of organized labor (Streeck, 1997), liberal economies are prone to faster devaluation that is less contained by the state (Rentier et al., 2019). Following the regulationist framework, historical analyses are key to better understanding regulatory trajectories in the devaluation of fossil fuels. A historical approach reveals not only the role of historical contingencies in energy transitions (Baker et al., 2014) but also how mutually embedded market and political factors evolve over time.

Coal exit plans, which have proliferated in recent years, are a new way to regulate devaluation. The plans seek to organize, rather than avoid, a shutdown of fixed capital. They normally involve a combination of ‘pushing-out’ (bans), ‘pricing-out’ (carbon taxes), and ‘paying-out’ (financial compensations) mechanisms, and often include a final date for coal extraction and/or burning (Furnaro, 2021). However, coal exit agreements do not necessarily accelerate phase-out processes (Rentier et al., 2019). Rather, phase-out plans establish a spatiotemporal boundary for the end of coal; their role in accelerating and distributing the costs of devaluation is yet to be determined.

The political economy of energy transitions literature has emphasized the importance of different modes of economic regulation in shaping transition processes (Baker et al., 2014). However, the specific modes of regulating devaluation of fixed capital remain under-researched. This paper addresses this gap using the German case. The following sections analyze the German coal exit plan, beginning with a historical overview of its regulatory roots, which were influenced by several devaluation crises that affected Germany’s coal industry from the 1870s to the 2000s.

3.3. Political economy of delay: regulatory roots of the German coal exit plan

From periodic (1870s–1950s) to progressive (1960s–1990s) devaluation

Until the mid-twentieth century, most coal sector crises in present-day Germany were related to cyclical economic downturns (Kitchen, 1978, Shearer, 2003). The Great Depression of 1873–1896 was especially significant. During and after this crisis, monopolization was used to overcome industrial competition by favoring price controls and increasing outputs. The Depression also promoted the vertical integration of coal and steel companies and accelerated the formation of industrial cartels. To resist devaluation in this and subsequent coal crises, the industry demanded protectionist tariffs and government expenditure on public infrastructure to incentivize exports (Kitchen, 1978). After World War II, the federal government subsidized coal and steel companies – the first time large shares of coal devaluation costs were transferred to the state (Yamazaki, 2013).

Since the mid-nineteenth century, strong collective bargaining processes have been the norm in the German coal industry (McGaughey, 2016). German capitalists used corporatist labor relations to reduce the risk of fixed capital devaluation by workers' sabotage. Indeed, sabotage was less common in Germany than in other coal-producing countries (though not totally absent (see Gillingham, 1982)). In 1951, Germany passed the Coal and Steel Co-Determination Law, which granted workers equal voting rights on the executive boards of companies (Van Hook, 2002). This new compromise between capital and labor is still a key feature of Germany's political economy, despite the significant erosion of workers' power since the 2000s (Nachtwey, 2016). The compact contributes to Germany's slow industrial upgrading. Fixed capital devaluation is slowed by negotiated economic management and state support to avoid abrupt job and capital losses (Streeck, 1997).

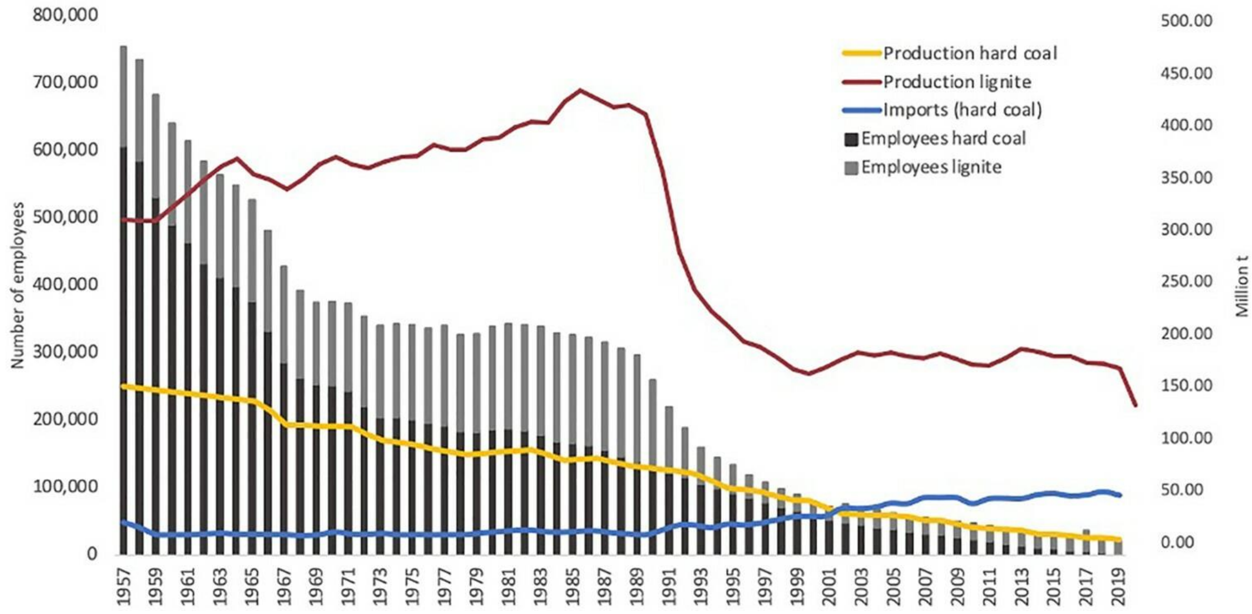
The 1960s marked a shift toward the progressive devaluation of coal. The hard coal mining industry, located exclusively in West Germany and considered the backbone of the post-war economic recovery, began to lose competitiveness after market liberalization facilitated more imports of oil and natural gas (Nonn, 2001, Storchmann, 2005). More than half of coal workers – some 320,000 people – were laid off within ten years (Herpich et al., 2018). Policies to protect production (tax benefits, investment aids, price subsidies) and hamper imports (a mineral oil tax, prohibition of oil-based power plants, and import coal quotas) continued to transfer the costs of devaluation to taxpayers (Storchmann, 2005). Electricity ratepayers also bore some of these costs through the Coal Penny (*Kohlepfennig*), an electricity surcharge (1975–1995). These subsidies were promoted by an alliance consisting of capitalists, unions from the coal and steel industries, and politicians, especially the social democrats (SPD) (Brauers et al., 2018).

Decommissioning premiums to reduce production were implemented since the 1960s to subsidize the final devaluation of individual mines and avoid a general devaluation of coal (Storchmann, 2005). In the late 1960s, monopolization was employed again via the consolidation of the Ruhr mining companies into one conglomeration. By the end of the 1960s, the first policies to promote diversification away from coal were implemented through infrastructural, technological, and educational programs. However, subsidies for the coal industry slowed this diversification (Oei et al., 2020). Private sector strategies such as lobbying practices and the hoarding of industrial land in the Ruhr Area were also used to resist devaluation (Lintz and

Schmude, 2005). Nevertheless, the pressures of progressive devaluation continued (Oei et al., 2020).

The devaluation of lignite was faster than hard coal. It occurred after reunification and was concentrated in East Germany, though lignite was historically mined across the country (in the Rhineland in West Germany and in Lusatia and the Central German Area in East Germany). A drop in demand caused by a general industrial decline in East Germany, combined with the fact that lignite production was more expensive and less productive than hard coal production in West Germany, spelt doom for the industry. Between 1989 and 1994, the lignite industry shed two-thirds of its workers (100,000 people) and decreased production by more than 50 per cent (Herpich et al., 2018) (see Figure 3). However, Germany remains among the top global lignite producers to date due to low operating costs, subsidies, and old infrastructure with already recovered capital (Brauers et al., 2020).

Figure 3. Coal production and direct employees in Germany (hard coal and lignite) and hard coal imports, 1957–2019.



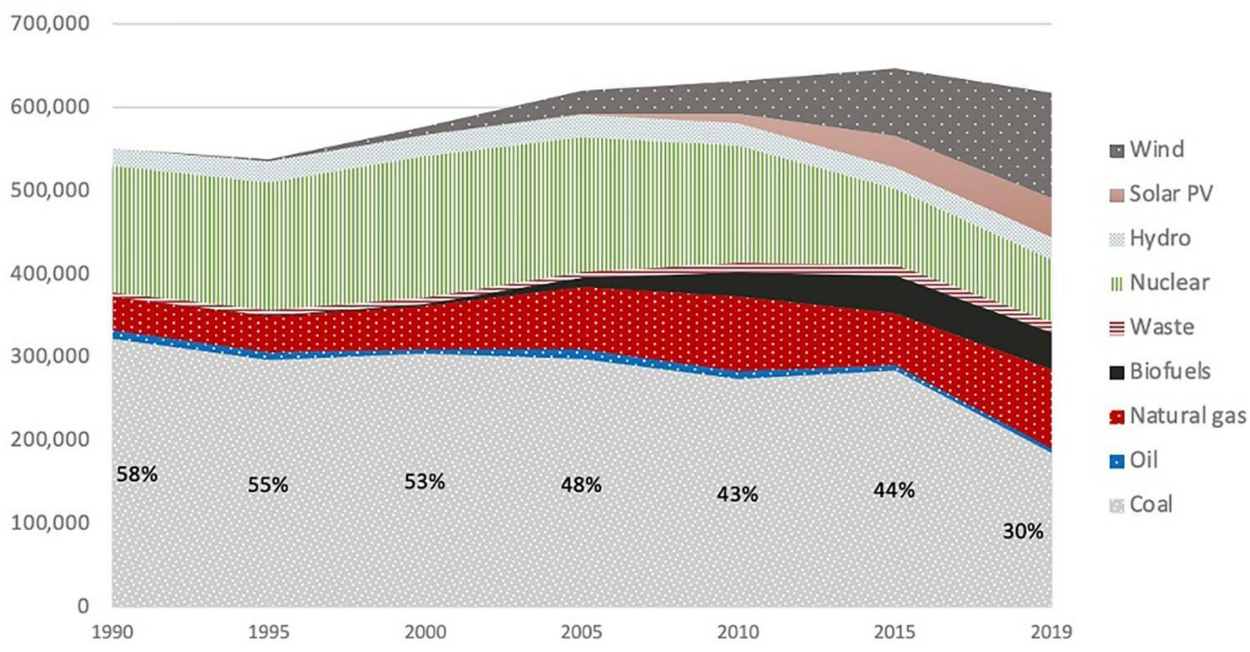
Sources: Herpich et al., 2018; statistik der kohlenwirtschaft, 2020; verein der kohleimporteure, 2020.

Environmental devaluation forces (2000–2020)

The steel market's demand for coal decreased between the 1960s and 1990s; however, coal's role in power generation increased substantially (Storchmann, 2005). Thus, the devaluation of coal mining in Germany has increasingly been attached to the role of coal in the power sector, which experienced a boom in investments after the oil crises of the 1970s (Pahle, 2010). Yet, the antinuclear concerns in the 1980s and 1990s spurred initial discussions about the need for the Energiewende (a sustainable transformation) (Paul, 2018). The Renewable Energy Source Act (EEG) implemented in 2000 supported renewable energies by giving them market priority and allocating abundant funds for research and development. However, the 2011 decision to phase out nuclear energy was a significant barrier for a coal decline. In this plan, which was part of the so-called Energiewende policy (Merkel's 2011 energy transition policy), seeing lignite as a bridge fuel and faith in carbon capture technologies made the need for a coal exit plan seem superfluous (Schreurs, 2013).

However, the role of renewable energies offsetting the nuclear phase-out does not fully explain the persistence of coal. Recent years saw huge electricity overcapacities allowing exports to increase from 42.08 TWh in 2000 to 72.40 in 2019 (25.19 TWh more than what was imported in 2019 (Agora, 2017)), and making Germany the world largest electricity exporter (IEA, 2020, Bundesnetzagentur & Bundeskartellamt, 2021). In this context, highly subsidized and economically more competitive renewable energies could not decrease coal usage (see Figure 4), with the late 2000s seeing a rise in coal power investments (Pahle, 2010). In addition to coal subsidies, low CO2 prices in the European Union Emissions Trading System (EU ETS) and high international gas prices also helped coal resist devaluation until about 2015 (Jungjohann and Morris, 2014).

Figure 4. Germany’s Power Mix, 1990–2020 (GWh)



Source: IEA (2022a).

In Germany, subsidies for renewable energies and coal coexisted until very recently (Van Der Burg and Pickard, 2015). From 1970 to 2012, €125 billion in subsidies went to renewable energies, €192 to hard coal, and €73 to lignite (Wronski and Fiedler, 2017). Subsidies for hard coal only began to diminish in 2007 when a law to end them by 2018 was passed under pressure from the EU’s competition policy (Oei et al., 2020). The pro-coal sector successfully pushed the final date from 2012 to 2018, when the last hard coal mine finally closed in Germany (Brauers et al., 2018). However, subsidies for lignite remained in place and coal imports continued (Van Der Burg and Pickard, 2015). Energy-intensive industries such as steel, aluminum, paper, chemical, and textiles also promoted this extension by claiming that a coal phase-out could disrupt supply security and price stability (Leipprand and Flachsland, 2018). These industries benefited from decreasing wholesale electricity prices associated with rising shares of renewables and overcapacities (Kemfert et al., 2015).

Since the 1990s, environmental pressures to devalue coal have been partially institutionalized by decarbonization and renewable energies policies. However, regulatory mechanisms to delay devaluation, especially coal subsidies, largely resisted this pressure. In 2019, though, a so-called coal exit compromise emerged since various stakeholders accepted the need for a coal exit plan, which political-economic conditions are analyzed in the following sections.

3.4. The coal exit compromise: the paying-out model as a condition

Discarding alternatives

The emergence of the coal exit compromise was relatively sudden and unexpected. As an energy consultant noted: 'until 2014 or 2015, a coal phase-out was a toxic word in German politics. The general notion was that you cannot decommission nuclear and coal at the same time.'[3] Similarly, a trade union representative observed: 'this really comes from nowhere. Suddenly this was on the table.'[4] One key precursor to the compromise was the lignite security reserve (*Braunkohle-Sicherheitsbereitschaft*) of 2016. This measure gradually placed eight lignite power plants (2.7 GW) on standby to be shut down after four years. However, given the low flexibility of lignite-fire stations (their inability to rapidly change their load capacity), already existing power capacity reserves in the country, and overcapacities, the standby reserve has not been used to produce power (Umpfenbach et al., 2019). The adoption of this pay-out model, in which the federal government financially compensates power plant operators, emerged in discussions after

[3] Energy expert, September 31, 2019.
[4] Representative trade union, August 15, 2019.

the Paris Agreement in 2015 motivated by the country's failure to achieve its climate goals by 2020 (Leipprand and Flachsland, 2018). According to a representative from the coal industry, these discussions signaled 'a starting point of a coal phase-out being a high-level political issue.'[5]

The main alternative to phasing out the eight power plants was a pricing-out mechanism based on a climate levy (*Klimabeitrag*). This model was supported by environmental groups, who said it would generate additional funds and avoid the costs of a pay-out approach (Amelang et al., 2016). However, it was resisted by the coal industry, especially the Trade Union for Mining, Chemicals and Energy Industries, which argued that a reserve system was needed for security of supply (IGBCE, 2015). The pay-out model also aligned with Germany's enduring tendency toward slow industrial upgrading financed by the state (Streeck, 1997). As a representative of an environmental consulting firm argues: 'This is the secret behind German economic policy, it always tries to avoid disruptive change.'[6] The use of a pushing-out model (coal bans) was never seriously considered as it lacked political support from the pro-coal sector, and because its previous use with nuclear energy proved legally risky and expensive for taxpayers.[7]

The devaluation crisis in the energy sector

An important condition for the emergence of the coal exit compromise was an ongoing devaluation affecting utility companies with coal capacity including RWE, Vattenfall, LEAG, EnBW and many smaller private and municipal utilities. The two central forces driving devaluation were CO2 prices increasing since 2018 in the EU ETS and natural gas prices

[5] Environmental manager utility company, July 18, 2019.
[6] Member CC, July 31, 2019.
[7] Member CC, July 31, 2019.

simultaneously decreasing. Divestment campaigns applied additional pressure on some coal companies and environmental litigation delayed the construction of some power stations while making the operation of existing ones economically riskier. Within this context, most hard coal-fired units in Germany were generating losses since at least 2018 (Matthes, 2018, Brown, 2020). Moreover, most of the units were constructed in the 1980s, meaning they were less efficient and competitive in the merit order, resulting in several closures (Oei and von Hirschhausen, 2019). Larger coal-fired power plants would also need to spend considerably on retrofitting to meet new EU Industrial Emissions Directive pollution requirements by 2021 (EEA, 2018).

This devaluation crisis affected the whole power industry, not just the coal sector. Real competition was occurring – maybe for the first time – among fossil fuel operators. Power overcapacity created by renewables' rising market shares and lower costs generated downward pressures on wholesale market prices and reduced capacity utilization since 2004 (BMWi, 2015, Auer and Heymann, 2019). This impacted the major utilities (E.on, RWE, Vattenfall and EnBW) (Kemfert et al., 2015). These utilities were also slow to incorporate renewable energies (Berlo and Wagner, 2015). The crisis led to the restructuring and writing-off of important assets around 2016, especially for E.on and RWE (Hornlein, 2019). Utilities with a large share of gas infrastructure, including many municipally-owned companies, were also affected by the decline in investments (VKU, 2017). Owners of nuclear assets (mostly E.on, RWE, and EnBW) also faced reduced expected revenues associated with the costs of dismantling nuclear infrastructure. As an energy expert put it, several power plant owners and operators had an "interest in doing the phase-out because once you remove a few plants off the market the other ones will get more profitable again."[8] Therefore, companies strategically promoted a subsidized individual devaluation of fixed capital to avoid a broader devaluation of the whole power sector.

The double legitimation crisis

Anti-coal protests and campaigns have escalated in Germany in recent years (Brock and Dunlap, 2018, Brauers et al., 2020). Germany also experienced extreme heat and drought in 2018 and 2019, which impacted agriculture, forests, and public perceptions. Public support for the Green Party increased while the environmental legitimacy of the federal government was damaged, especially by its inability to meet its climate compromises by 2020. Therefore, significant pressure existed to incorporate stricter decarbonization measures and sectoral targets in the Climate Action Plan 2050 (Oei et al., 2017). At the same time, the government coalition faced a separate legitimacy crisis in Eastern lignite states. This was highlighted by the 2017 general elections in which the far-right party, Alternative für Deutschland (AfD), received elevated support, including second majorities in Brandenburg (23 per cent) and Saxony (27.5 per cent) (Bose et al., 2019, Nasr, 2019, Herberg et al., 2020). Lignite regions also experienced a violent surge in far-right extremism during the 1990s after the fast devaluation of lignite and general industrial decline. Residents and politicians frequently recall this period when describing the challenges of the current coal phase-out.[9] The rise of far-right populism in these regions cannot be reduced to the devaluation of lignite (the most important remaining industry) or a general economic downturn.[10] However, real and perceived economic decline and the expected devaluation of labor associated with the phase-out of lignite are important factors in this

[8] Energy expert, June 7, 2019.
[9] Energy labor expert, April 22, 2021.
[10] Despite being among the poorest in the country, these lignite regions have experienced slight improvements in terms of economic growth and employment since the 2000s (Walk and Stognief, 2021).

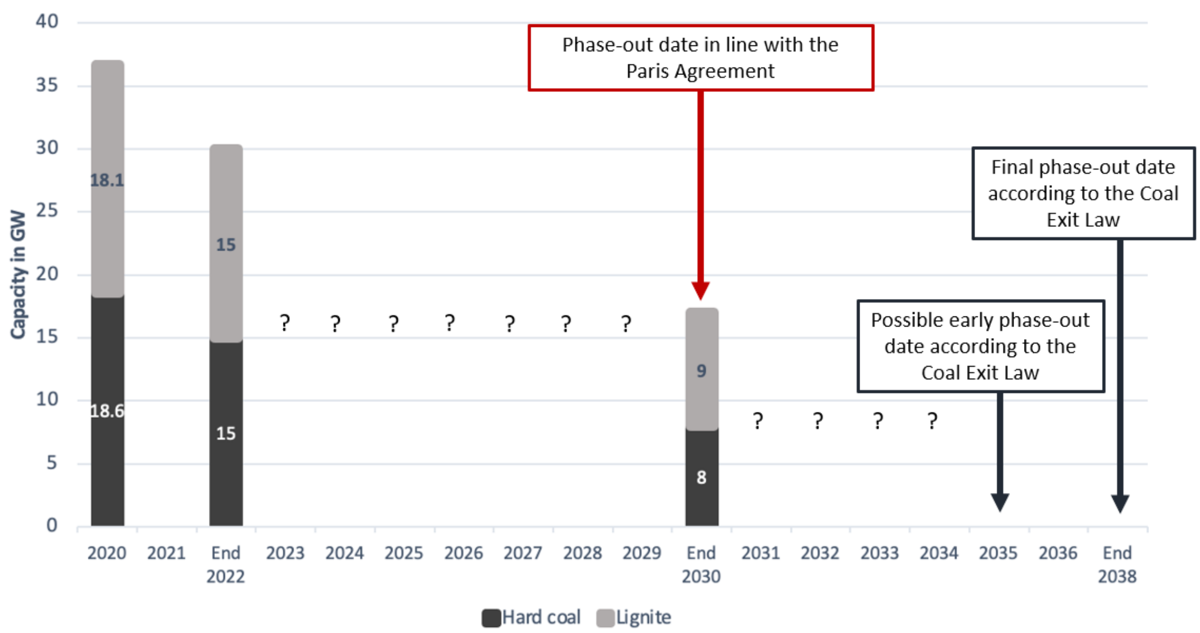
legitimacy crisis, commonly described as a ‘transformation fatigue’ (Dörre et al., 2018, Radtke et al., 2019). One of the AfD’s key messages in Eastern Germany is a defense of coal production against the supposedly elitist urban environmental agenda. In this context, the federal government worried that a coal exit agreement might embolden AfD voters. An energy expert who participated in the design of the Coal Exit Law explains: “the upcoming [2019] regional elections in the lignite states of Saxony and Brandenburg put a lot of pressure … The agreement needed to be done before these elections because it would definitely influence them.”[11]

Representatives of coal regions saw a negotiated phase-out as an opportunity to rapidly gain access to public funds. The federal government and traditional parties understood it as a tool to address, at least in part, the double legitimation crisis caused by simultaneous environmental claims and the expansion of far right-populism in lignite regions.[12] A national Coal Commission was convened in June 2018, two years after the idea of a commission was first discussed. The Commission brought together trade unions, industry organizations, lignite regions, energy experts, environmental NGOs, and representatives of lignite Länder. A year later, it recommended closing the 84 remaining coal-fired plants by 2038, with an option for an early closure by 2035 (see Figure 5). The final date, the more controversial dimension to be agreed upon, was not discussed until the last night of the last meeting. In contrast, when the Commission started there was already an implicit consensus on the use of a paying-out model, based on the lignite standby security agreement of 2015. As one participant explains, “it was

[11] Interview with Member CC, July 23, 2019.
[12] Interview with member of the Commission and representative of a mining region, August 2020 (conducted by Coal Exit Group); Energy labor expert, April 22, 2021.

clear from the beginning that it would be a phase-out with compensations."[13] Therefore, the Commission was less a governance tool to define the coal exit model, and more a forum to legitimate an already defined pay-out model. Most of the real discussion focused on refining recommendations to support the future economic development of lignite regions.

Figure 5. Coal exit schedule



Source: the author

Multistakeholder commissions have long been part of Germany's corporatist policy decisions (Hall and Soskice, 2001) and Merkel's 2018 government included more than 20 policy commissions. The Coal Commission, one of the most politically contentious, was itself influenced by the Ethics Commission convened in 2011 to outline the nuclear phase-out

[13] Member CC, July 23, 2019

(Reitznenstein and Popp, 2019). As several interviewees observed,[14] the Commission was a tool for the federal government to externalize the politically difficult decision around the future of coal. The agreement was approved by 27 of the 28 voting members, far exceeding the two-thirds requirement. Achieving this level of consensus was understood to be a political requirement to legitimate the coal exit plan.[15]

While new anti-coal protests have emerged since the Commission's recommendations were published in 2019, the anti-coal movement relatively weakened (at least in the months following the conclusion of the agreement). One representative from an environmental organization explained, "[The anti-coal movement] wasn't really pacified but the story was told. After the Commission, we moved our priority to mobility, transportation."[16] By including environmental organizations in the Commission, but not representatives of social movements such as Ende Gelände and Extinction Rebellion, existing fractures within the movement were exacerbated. The divide between NGOs, especially ones that signed the agreement, and more radical sectors in the environmentalist sector deepened, raising questions about the depoliticizing effects of the Commission (Selk et al., 2019).

[14] Energy politics expert, July 8, 2019a; Member CC, July 23, 2019; Energy expert, September 31, 2019.
[15] Interview with member of the Commission, November 2020 (conducted by Coal Exit Group).
[16] Representative political foundation, April 22, 2021.

3.5. The final state aid

Outlining compensation payments[17]

While the coal industry tends to support the Commission's recommendations, many actors from the environmental sector remain unsatisfied. From their perspective, the agreement was disproportionately influenced by the industrial sector, unions, and prime ministers of lignite regions. They reiterate that the final date of 2038 does not align with the Paris Agreement[18] and offers too much compensation to coal companies. Parts of the agreement were codified in two laws: the Structural Reinforcement Act for Mining Regions (*Investitionsgesetz Kohleregionen*) adopted in August 2019 and The Coal Phase-out Law (*Kohleausstiegsgesetz*) adopted in July 2020. The Coal Phase-out Law, however, does not include the Commission's recommended linear phase-out schedule, which was considered the environmental sector's main success. While the phase-out agenda can achieve the sectoral goals for 2030, many shutdowns will take place only at the end of the 2030s.

Bilateral contracts to financially compensate the lignite companies (€2.6 billion for RWE and €1.75 for LEAG) were determined in private negotiations with the federal government. Environmental groups have criticized these contracts for their lack of transparency, for being too generous considering declining profitability, and for foreclosing a potentially cheaper renegotiation for earlier dates and additional decarbonization regulations targeting the lignite

[17] This paper focuses on the financial compensation for utilities (€ bn 5–10), setting aside others forms of compensation that are important in this model, including the structural support for regions (€ bn 40), compensations for the increased electricity prices (€ bn 16–32) and early retirement compensation for workers (€ bn 5–7) (See Litz et al., 2019).
[18] Recent estimates show that Germany must shut down all coal capacity by 2030, not 2038, to meet its climate obligations under the Paris Agreement (Yanguas et al., 2018).

industry (ClientEarth, 2020b). At the same time, the government denied that a formula was used to calculate the compensations. However, as an environmental lawyer observes,

> [t]his formula was recently leaked by Greenpeace. And it is quite strange, because if you enter all the parameters into the formula, you reach this compensation amount. But the government said no, we did not use the formula, there is no formula, there is nothing objective, all of this is a negotiation result … by saying this is a negotiation result is also tricky to attack.[19]

Using private negotiations instead of disclosing a compensation formula hinders the (re)politicization of the discussion. Moreover, the generous compensations are justified as providing legal and planning certainty. Per the agreement, lignite operators waive their right to legal remedies against the German state, avoiding the potential costs of litigation experienced during the nuclear phase-out (ClientEarth, 2020b). However, according to several German lawyers, this argument is flawed: a comprehensively regulated phase-out plan with lower or no compensations, programmed with enough time, and justified under the need to mitigate the climate crisis could have also prevented litigation (Schomerus and Franßen, 2018, ClientEarth, 2020a).

The compensations to hard coal power operators are based on an auctioning mechanism that distributes decommissioning premiums to bidders that offer lower prices to retire a higher amount of MW. The law defines bid limit values for the auctions and progressively reduces price limits over time, from €165,000 per MW (net capacity) in 2020 to €89,000 in 2017 (ClientEarth, 2020a). The auctioning processes will continue until 2027, when there should still be enough

[19] Legal expert, July 9, 2021. See also Flunes, 2022.

operators to compete. From 2031, the retirement schedule will be based on statutory reductions without compensation. The first auctions were oversubscribed (Brown, 2020) and subsequent critiques emerged against this mechanism for overcompensating operators with declining, or even negative, profitability (for example, Bremen-Hafen 6 and Duisburg Walsum 9). Moreover, the first auctions resulted in the closure of younger, more efficient, and less polluting units, including winning bids for five-year-old stations (Vattenfall's 1600 MW Hamburg-Moorburg plant and RWE's 764 MW Westfalen plant).

The policy vs. market divide

Falling profitability has not been part of the pro-coal discourse in the debate around the phase-out of coal, despite the important role of the devaluation crisis in the emergence of a coal exit compromise. Rather, the key reason to participate in the Commission according to the public discourse of coal companies was planning security against a policy-driven coal phase-out.[20] The interpretation of the coal phase-out as a purely policy-driven process was also promoted by representatives of lignite regions. As a member of the Commission explains, "something that was very much expressed by the local politicians in these regions is that this industry is competitive and now the politicians make this decision that we have to close our business."[21] To hide falling profitability, coal companies tended to inflate financial statements (Eriksen, 2019), a strategy also used during the implementation of the lignite security reserve. They used historical figures (with higher profitability) to estimate potential devaluation costs. Risk management strategies included overestimating the economic viability of coal units through the use of future

[20] Environmental manager utility company, July 18, 2019.
[21] Member CC, April 21, 2021.

energy contracts and hedging in EBITDA estimates (Gray, 2020). Moreover, many financial metrics were not publicly available, which limited accountability and allowed an overestimation of policy-induced devaluation costs (Amelang and Wettengel, 2019).

On the other side, important factions of the German environmental sector, which traditionally supported strong state interventions to promote renewable energies, now relied on a more pro-market narrative to discuss and assess the coal phase-out plan (Kölle for Future, 2020). Some have even argued that the Coal Exit Law delays the actual coal phase-out, compared to the speed of market pressures. While this may be true for power stations more than 25 years old, the argument is difficult to generalize given coal stations' ability to operate under high devaluation pressures and tiny margins.[22] Moreover, the diversity of contractual conditions allows some operators of uneconomical plants to profit by transferring devaluation costs to power purchasing companies.[23] This pro-market narrative supports a more "market-driven" coal exit based on pricing-out mechanisms, where mechanisms such as the UK's floor price, are considered "more progressive"[24] than Germany's pay-out model. About the German environmentalist sector's renewed interest in carbon pricing, an energy expert observes,

> In the early years, [carbon pricing] was seen as an obsession of economists. We can just subsidize renewables. This was the early narrative of people on the green or left side of the spectrum, and then something happened and that was the observation that even though you subsidize renewables substantially you cannot push coal out of the

[22] Energy expert, May 31, 2021.
[23] See for example the case of Datteln 4, in which RWE and Deutsche Bahn have to pay for the operational costs, even if power is not produced; Interview with representative of environmental organisation in charge of several litigations against coal power stations in Germany, 09 July 2021.
[24] Representative political foundation, April 22, 2021.

> system … with the rising prices in the EU ETS it becomes empirically evident that they [carbon pricing mechanisms] are doing the job so no one is ignoring it anymore.[25]

Therefore, to capture higher compensation, the coal sector promoted the idea that the phase-out was driven by environmental policy, not market conditions. The environmentalist sector was unable to create a timely reinterpretation of market competition, as an ensemble of socially mediated devaluation forces, in driving the coal exit agreement in the first place. This framing only took hold after the model was implemented and compensation amounts were quantified, and now is central to discussions about the legality of the compensation payments.

3.6. Conclusions

This paper described the history of how coal devaluation in Germany has been regulated. It showed that a mode of regulation based on negotiated processes and large amounts of public financial support has effectively slowed down coal devaluation for decades. Using an historical approach as well as one that distinguishes between devaluation forces and coal devaluation as an outcome were useful to show why Germany, although having enacted the world's largest commitment to phasing out coal, has had a slow phase-out in relation to the longevity and amount of existing economic and environmental devaluation forces.

Employing a devaluation theory was helpful to understand resistance to phasing out coal, not only as the result of the different strategies employed by the pro-coal sector, but also as part of more perduring, although dynamic, forms of regulating devaluation, attached to the country's political economy. By describing the tendency of Germany's political economy to regulate coal devaluation by slowing down the process through state support, we can better understand the

[25] Carbon markets expert, July 16, 2021.

types of tools that were available for and preferred by the coalition of unions, companies, and politicians to resist coal devaluation and influence its regulation. From this perspective, it was clear that the 'when' and 'how' of the German coal exit plan were deeply linked, with the agreement on a paying-out mechanism being a condition for a coal exit date.

Furthermore, as the German case shows, a devaluation theory is useful to study how renewable energies can effectively replace fossil fuels, a challenge that can take different forms in countries with different modes of regulating devaluation. Coal subsidies vis-à-vis public support for renewables energies was part of a political economy where value creation in the renewable energy sector was easier to catalyze than direct coal devaluation. Given the powerful role of the coal industry in Germany's corporatist political economy and a tendency towards slowing down devaluation, economic and technological competition by renewable energies was not enough to push coal out of the market.

By using a relational political-economic approach, this paper framed the phase-out processes beyond a policy vs. market-driven binary. Phase-out processes always represent complex articulations between socially-mediated energy markets and economically-shaped political institutions (Jessop, 2001). Defining a phase-out agenda by a multistakeholder commission does not mean that the German coal phase-out is purely political, just as a rapid phase-out driven by market signals is hardly a purely economic process (Furnaro, 2021). More relevant is understanding how these articulations take shape in specific conjunctures. In Germany, market signals played a significant role in defining the timing of the Commission (when higher EU ETS prices and overcapacities were affecting profitability in the coal sector). Political relations were key in defining the mechanisms used to regulate devaluation and the final dates, with the selection of a pay-out model being attached to Germany's institutional memory to appease devaluation as well as to the power of coal- and energy-intensive firms and trade unions opposing alternative options. The political vs. market binary can constitute, however, a powerful narrative. By emphasizing the political drivers of the coal exit plan, the pro-coal sector improved its capacity to capture compensation payments, while the environmentalist sector was unable to timely reinterpret the relevance of market competition in making the paying-out mechanism too expensive.

In Germany, negotiation processes promoted depoliticization through not only the Coal Commission but also the closed-door negotiations between the government and coal companies. A deeper analyzing of the depoliticization effects of different forms of regulating coal devaluation can be an important area for future research. Another important avenue for future research on regulating devaluation is related to the double legitimation crisis, a conundrum that is not unique to the German state. In Germany, we saw an attempt to address it by increasing economic support to coal regions affected by devaluation while providing a coal exit date to respond to environmental pressures. More needs to be said about how different forms of regulating devaluation can address and transform this double legitimation crisis.

CHAPTER 4. GEOGRAPHIES OF DEVALUATION

4.1. Introduction

In 2020, Germany enacted the Coal Exit Law, which set 2038 as the final possible date for the extraction of coal and its use in power production, putting an end to a long coal history in the country. The coal exit plan also represents a new moment of the *Energiewende*, Germany's energy transition, which historically prioritized the phase-out of nuclear power and phase-in of renewables, but is now increasingly focused on coal. Although energy geographers have analyzed the *Energiewende* by emphasizing the spatial dimensions of new renewable energies (Becker et al., 2017; Faller, 2016; Gailing, 2019; Gailing et al., 2020; Paul, 2018), the coal phase-out has not been equally examined. This is a major gap for the geographic understanding of the German energy transitions given the necessary role of phase-out processes for genuine decarbonization (IEA, 2021).

This paper examines the geographies of the German coal exit from the perspective of the moral devaluation of fossil fuels, which emphasizes the embeddedness of political-economic forces and forms of regulating the devaluation of fixed capital in the fossil fuel sector (Furnaro, 2021; Furnaro 2022). These geographies are analyzed by looking at the interaction of different spatial dimensions (Jessop et al., 2008; Gailing et al., 2019) as well as conditions and practices associated with the shutdown of fossil fuel infrastructure. It describes how changing combinations of sociospatialities shape and are shaped by the devaluation of coal.

It will be argued that although the German coal exit plan represents a national arrangement, it was not primarily driven at the national scale. Rather, central devaluation pressures that triggered the plan were created by place-based anti-coal networks and international energy and carbon market relations. Although the emergence of a national-scale "fix" was important to regulate not only existing economic devaluation forces but also a double legitimacy crisis for the government, the spatially uneven character of this fix was also key.

The rest of this chapter is organized as follows: Section 2 presents the theoretical framework. Section 3 provides an overview of the methodology employed. Section 4 describes the history of the German coal phase-out and current exit plan. Section 5 presents the results and main arguments of this article in three subsections, which describe the sociospatial dimensions of key forms of promoting, resisting, and regulating the final devaluation of German coal. Finally, a discussion around the implications of this case is presented.

4.2. Spatialities of devaluation

Decarbonization will increasingly lead to the devaluation of infrastructure and other fixed capital associated with the fossil fuel industry, including mines, wells, power stations, refineries, and pipes (Carton, 2019; McCarthy, 2015; Smith, 2017). Drawing on theories of capital devaluation, fixed capital devaluation corresponds to the process through which still-operative fossil fuel infrastructure loses value (Harvey, 1982). According to Smith (2017), some of the most common types of devaluation in capitalist economies are "progressive" (i.e., the ceaseless process of devaluation of fixed capital because of market and technological competition) and "periodic" (i.e., devaluation taking place during general economic crises). To better account for the social dynamics and moral claims that shape the devaluation of fossil fuels, the concept of moral devaluation accentuates the socially-embedded character of energy markets as well as the relationality between economic and extraeconomic practices to promote, resist, and regulate how fixed fossil fuel capital loses value in capitalist economies (Furnaro, 2021: p.5).

The moral devaluation of fossil fuels involves complex sociospatial processes. According to Harvey (1982:387), fixed capital devaluation is always place-specific and its location is defined in large part by the anarchic forces of industrial competition. This is also the case with fossil fuels. Techno-economic and political factors help to partially understand where devaluation, which always affects fixed capital at a particular location, materializes first. In terms of vertical spatial organizations, forces of devaluation depend on the scales on which energy markets operate (e.g., global fossil fuel markets, domestic electricity markets) in combination with practices of territorial bordering that define their regulation (cf. Nciri & Miller, 2017). In terms of networks, or the horizontal relationality of spaces, they depend on processes happening somewhere else (e.g., diffusion of technologies or policies) (Brauers et al., 2020; Rentier et al., 2019).

Some decarbonization policies, such as carbon taxes and emission caps, are increasingly important and are territorially-defined devaluation forces. Anti-fossil fuel campaigns have promoted these policies as well as more direct forms of devaluation by targeting specific infrastructures through legal and reputational tactics organized by local, national, and international networks (Gürtler et al., 2021; Rootes, 2013). Rescaling litigation to international courts and relocating it to different jurisdictions are common spatial tactics of devaluation (Osofsky, 2005). In fossil fuel industries, devaluation that affects specific firms or operations, what Smith (2017) describes as "individual" capital, is a common place-based strategy to create revaluation in the whole industry of a country or region (or "general" capital) in times of oversupply (Huber, 2011). Processes of revaluation have led to different forms of "carbon leakages," a spatial concept that signals how devaluation in certain places lead to the revaluation of fixed fossil fuel capital in less environmentally regulated jurisdictions (Kama, 2014).

Regulating devaluation involves practices of resistance and the governance of devaluation forces, which are all spatial processes. Fossil fuel workers and capitalists have resisted devaluation through multi-scalar lobbying (Seto et al., 2016). Resistance is often rescaled to the national level, given not only the national influence of anti-devaluation interests but also the roles of the state in reducing the pace of devaluation (Harvey, 1982) and devolving to internal political processes the constraints of world market competition (Hirsch, 1994). In the case of fossil fuels, this is also related to the strategic role of these industries for energy security and government revenues, and of their fixed capital in practices of territorialization (Bouzarovski et al., 2015; Bridge, 2010). Fossil fuel exit plans represent a relatively new form of regulating devaluation in which the total shutdown of infrastructure is organized rather than avoided. Up until now, most of these plans have been enacted at the national level and focused on coal and the power sector (Diluiso et al., 2021). These policies share a gradual phase-out approach but different financing mechanisms, based on paying-out, pushing-out, and selling-out models, which tend to be coherent with domestic styles of economic governance (Rentier et al., 2019). Many cities and regions, through for example, stronger climate policies or carbon markets, have their own exit plans or shape the national ones (Furnaro & Kay, 2022).

The costs of fixed capital devaluation are also spatial phenomena, including the distribution of losses for operators and owners of fixed capital. Variegated forms of attending to these costs (e.g., by transferring them to ratepayers in some states of the U.S. or to taxpayers in Germany) depend on different modes of regulating devaluation in the energy sector (e.g., through bankruptcy laws) (Caldecott & McDaniels, 2014). Moreover, concomitant impacts of devaluation, particularly unemployment, economic decline, and environmental degradation, tend to disproportionally affect regions economically dependent on fossil fuel industries, potentially creating new forms of spatial inequality driven by decarbonization policies (Garvey et al., 2022).

4.3. Methodology

This paper is based on an in-depth case study of the German coal phase-out. A case study is a research approach that employs multiple methodologies and sources of evidence to investigate a contemporary phenomenon (Noor, 2008). Case studies are interpretative because they emphasize processes and meanings rather than measurements and quantifications, being especially useful to understanding how and why things happen (Mabry, 2008). Therefore, this approach was useful to understanding how and why the coal phase-out has been spatially organized. The case study was based on 90 interviews with actors associated with the coal phase-out conducted between 2019-2022. Interviews included members of the Coal Commission, energy experts, climate activists, representatives of NGOs, state and public institutions, trade unions, utility companies, political parties, energy-intensive industries, and business associations. The specific institutions associated with each interviewee are not disclosed in this paper to protect their identities. Purposive sampling was used to achieve maximum information and variation possible (cf. Kemper et al., 2003). The analysis was also based on the review of policy documents, press releases, company reports, and news articles. The qualitative software Atlas TI was used to organize and analyze the large quantity of material collected. An open-axial-selective coding process was employed (Strauss and Corbin, 1990). Coding played a key role not only for controlling evidence but also to generating theoretical reflections.

4.4. The German coal exit: Geohistorical overview

The current coal phase-out process in Germany started many years before the recent Coal Exit Law. International forces were the main drivers of devaluation in 20th century Germany. In the case of hard coal, before the 1960s, periodic forms of devaluations were predominant, caused by overproduction crises affecting the global economy and creating general devaluation (Kitchen, 1978). During the two world wars, geopolitical factors became very relevant, creating fixed capital devaluation associated with excessive demand and overuse (Fay et al., 1941; Gillingham, 1982:641). It was not until the late 1950s that the progressive devaluation of the hard coal industry was triggered by international competition (Brauers et al., 2018). Geopolitical relations were also important through the incorporation of Germany into the European Coal and Steel Community, which meant the suspension of coal price regulations (Storchmann, 2005).

Given the importance that the coal and steel industry[26] had in the national economy, many practices to resist devaluation took place at the national scale through protectionist policies such as tariffs, quotas, and import taxes reducing the pace of the decline of production (Oei et al., 2020; Storchmann, 2005). From 1967-1987, the national government and coal federal state of North Rhine-Westphalia (NRW), which was home to the hard coal industry, provided decommissioning premiums for individual coal investments to vitalize the industry in general (Storchmann, 2005). Programs to assist hard coal regions by promoting the modernization of the industry also contributed to this resistance. These were financed by the national government and the coal *Länder* of NRW and Saarland, and later, by the European Community and EU as well (Furnaro et al., 2021). This approach was part of a Keynesian crisis-management strategy to

[26] Due to the vertical integration that characterized coal and steel production in Germany until the 1960s, it was common to describe both activities as a unitary industry (Van Hook, 2002).

subsidize growth in lagging areas, predominant in post-war Germany until the 1980s (Brenner, 2000). By addressing these devaluation pressures at the national scale, Germany was also able to reduce the concomitant labor impacts, offering support to virtually all affected coal workers (Goch, 2002). Lobbying by networks of local politicians (especially from the Social Democratic Party or SPD), unions, and capitalists served to upscale devaluation pressures from coal regions into *Länder* and national responses (Goch, 2002; Leipprand & Flachsland, 2018).

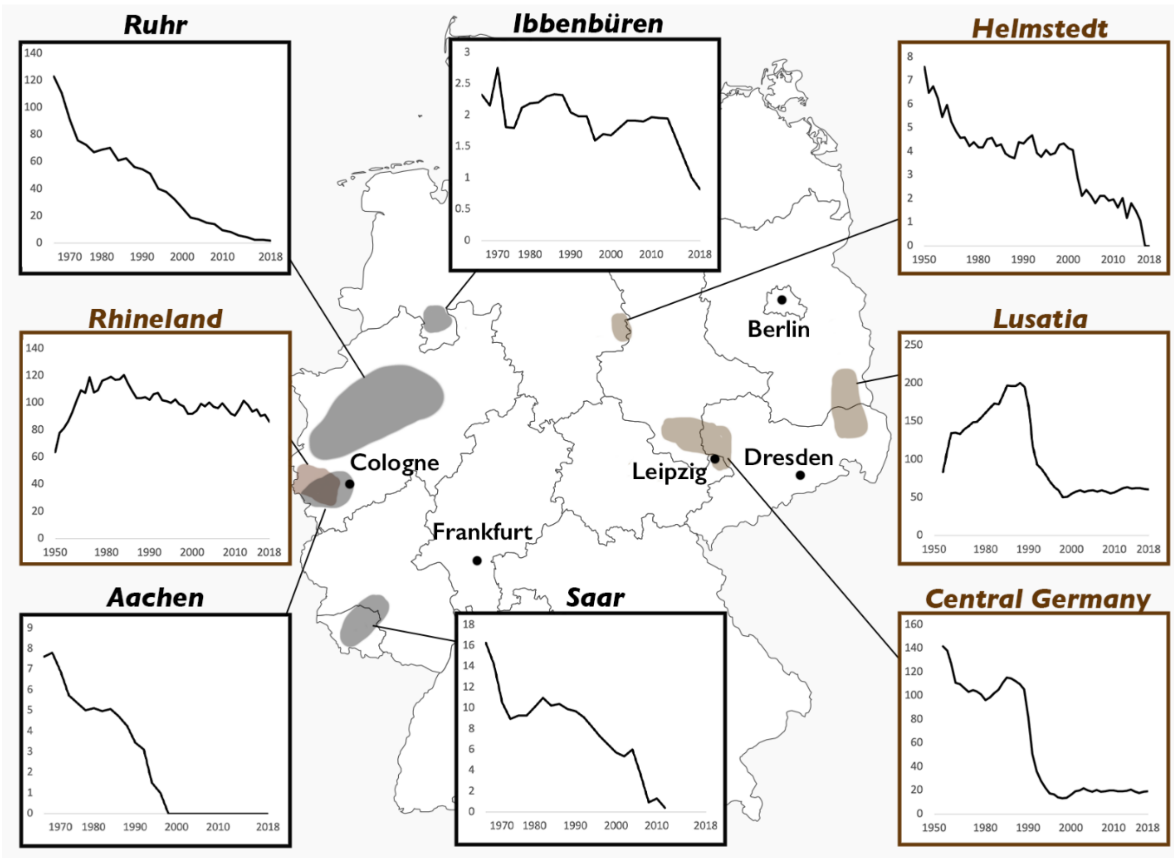
A different force of devaluation emerged in the 1990s, prompting the decline in lignite production after the reterritorialization of the national market by reunification. With the industrial decline in Eastern Germany, less lignite, which was the main fuel of the German Democratic Republic, was mined and consumed (Michel, 2008). Reunification also meant the privatization of the lignite industry in Eastern Germany (largely acquired by West German investors), with massive shutdown of less profitable operations to justify their acquisitions, and the introduction of West German production standards that created further shutdowns and layoffs (Bose et al., 2019). In this case, a national devaluation force strongly affected the regions of Lusatia and Central Germany rather than the general industry (see Figures 6 and 7). In the 1990s, devaluation was much less subsidized, and massive economic decline and unemployment were created. This represented a change away from the developmentalist model through which the state promoted a balanced growth of the national economy. In contrast, since the 1990s, more distinctive and competitive spatial development trajectories have unfolded (Brenner, 2000). In this new form of regulating devaluation, national policies were "incapable of and/or unwilling to raise the economic standard of the east to that of western Germany" (Förtner et al., 2021).

The 1980s also saw the emergence *Energiewende*, which, in a broad sense, refers to a major shift in Germany's energy system. Initial debates around the *Energiewende* focused on the need to replace nuclear energy for safety reasons and oil for energy security reasons, especially through renewable power, while coal was seen as a needed bridge fuel for this goal (Hirschhausen, 2018). Although the expansion of renewables since the 1990s gradually decreased wholesale power prices, making coal-fired generation less competitive, it was unable to push coal out of the market given the 2011 decision to phase out nuclear power by 2021, existing overcapacities, and subsidies (Oei et al., 2020; Van Der Burg & Pickard, 2015). The nuclear exit decision was part of the *Energiewende* in a strict sense, i.e., Chancellor Angela Merkel's 2011 energy policy for the transition towards "a renewables-based energy system with no nuclear energy and little coal" (Hirschhausen, 2018:p.34).

Pressure to phase out coal, however, has mounted since the mid-2010s (Brauers et al., 2020; Oei et al., 2020). In 2007, a law to phase out hard coal subsidies was enacted; this drove the final devaluation of hard coal mines, the last one of which closed in 2018. However, Germany kept importing hard coal and producing and burning lignite in three regions: Lusatia, Central Germany, and the Rhineland. The future of coal became a central political debate in Germany in the late 2010s. In 2019, the federal government convened the Coal Commission, a multi-stakeholder group in charge of recommending a coal exit plan. One year later, a Coal Exit Law was enacted, defining 2038 as the last possible date for coal extraction and burning (Gürtler et al., 2021). This exit plan included abundant financial compensation to the two lignite companies LEAG (1.75 billion) and RWE (2.6 billion) (under assessment by the EU competition policy at the time of writing) and a tendering process for hard coal power stations that will grant decommissioning premiums until 2027.

The following section presents some of the main spatial features of this exit plan organized in three subsections, each of which is related to three key moments of moral devaluation: devaluation forces, forms of resistance, and regulatory responses.

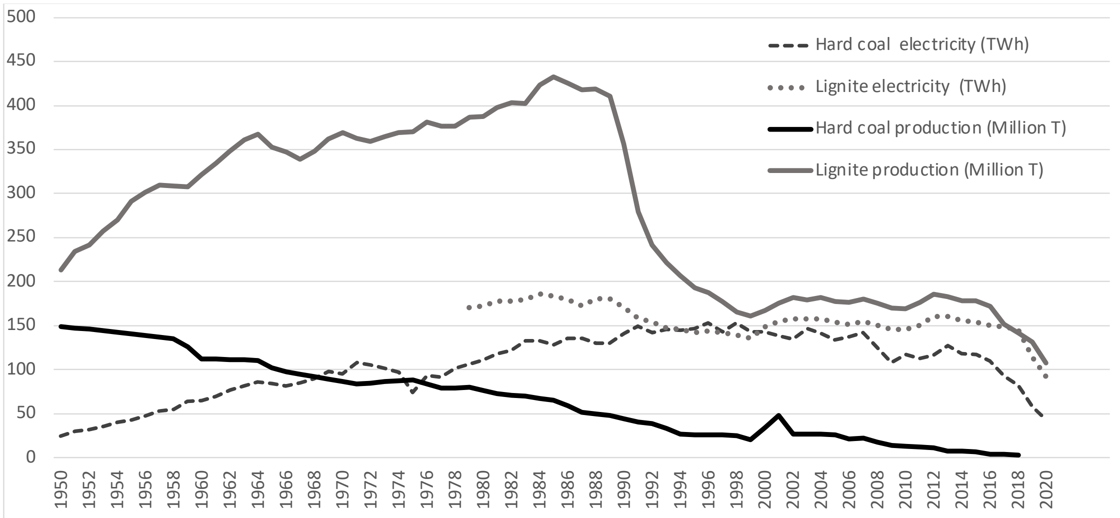
Figure 6. Coal and lignite production in Germany by region (1)(2)



Source: made by the author with data from kohlenstatistik.de

(1) Data expressed in 1000 t; (2) This figure does not include the smaller lignite regions of Bayern and Hessen, where extraction practically disappeared in the 1980s and 1990s, respectively.

Figure 7. Coal and lignite extraction and power production in Germany (1)



Source: Statistik der Kohlenwirtschaft e.V., 2022

(1) Data from 1950-1990 corresponds to the sum of East and West Germany. Information on lignite electricity in East Germany is only available from 1980 onwards.

4.5. Geographies of the German coal exit

Devaluation forces

The *Energiewende* has commonly been described as having a national origin (Gailing and Röhring 2016:13). This section will show that central political and economic triggers of the coal phase-out have to do with international markets and place-based political networks, respectively.

In terms of international markets, the EU is an especially relevant scale of devaluation by increasingly regulating the operation of European energy and carbon markets, as physical and commercial networks in which the German coal industry is embedded. For example, new EU competition rules led to the decision in Germany to phase out hard coal mining subsidies in 2007 (Oei et al., 2020). In the case of coal-fired stations, most interviewees agreed that one of the most powerful market forces of devaluation was the rise in carbon prices in the late 2010s, after the strengthening of the European Emission Trading System (EU ETS). Secondly, the decline in prices of imported natural gas have reduced hard coal utilization rates and its role in the electricity mix since 2017 (Agora-Energiewende, 2020). Other international forces of coal devaluation were not mediated by market mechanisms but by political ones. This is the case of inter-scalar pressures created by global climate commitments, particularly the Paris Agreement, which Germany was failing to meet by 2020, as well as horizontal pressures created by announcements of coal exit plans by other European countries.[27] Regulatory changes at the EU level, especially in terms of pollution standards, are additional vertical devaluation forces for German coal. However, their enactment and enforcement have been strongly resisted by the German coal industry (Brauers et al., 2020).

A central political force of coal devaluation that started to gain relevance at the end of the 1990s was the social pressure exerted by the anti-coal network, for which local embeddedness has been key (Sander, 2016). This corresponds to dense interactions of activists, NGOs, local communities, and scholars, among other actors and organizations operating in different regions and on different scales. Internal differences are common in this network, particularly between more radical fractions and "professional" NGOs (both with differences within) (Kalt, 2021; Krüger, 2021). The first anti-coal campaigns against lignite in NRW during the 1990s were already led by regional organizations.[28] The investment boom in coal-fired stations in the 2000s triggered more coordinated campaigns all over Germany, including those against lignite mines in the Rhineland and Lusatia (Morton & Müller, 2016). The place-based character of the anti-coal

[27] Energy expert, January 19, 2021.
[28] Member CC, December 3, 2020.

network was accentuated once the climate movement started to emphasize the local scale in the late 2000s (Sander, 2016). Emphasis on the local scale was a strategy to bypass not only the global scale, after frustrating attempts by the climate movement in the 2000s, but also the national scale: "At the domestic level, there was no chance to get this addressed."[29] Networking with national organizations also became a scalar strategy sought by local organizations to gain financial, legal, and organizational support.[30]

Local embeddedness has also been key for litigation against coal, one of the prominent strategies to devalue individual coal capital by the anti-coal network. This strategy has been based on claims filed with local and national courts related to environmental, health, administrative, and property rights issues (Hahn & von Fromberg, 2021), normally coordinated by NGOs in cooperation with environmental law organizations (Mez, 2021). Local embeddedness is key in this strategy given *locus standi*, an admissibility criterion that challenges public interest litigants due to the requirement, in many issues, that claims need to concern the rights of natural persons (Peel & Markey-Towler, 2021). In the case of lignite, networks connecting different villages and NGOs across Germany legally defended properties at risk of expropriation by the expansion of open-pit mines.[31]

Local sabotage organized by networks of activists have also devalued individual coal capital, although often only temporarily (Scherhaufer et al., 2021). More important forces of general devaluation have been massive demonstrations held in large cities and coal regions, which

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[29] NGO representative, June 8, 2021.
[30] NGO representative, July 22, 2021.
[31] See, for example, the initiative *Menschenrecht vor Bergrecht* ("human rights before mining rights") in the Rhenish region and *Alle Dörfer Bleiben* ("all villages stay"), a network of villages in the three lignite regions.

attracted media presence and helped legitimize the movement nationally. Mobility by commuter activists, often students from larger cities such as Cologne or Berlin, has been a key spatial strategy in this regard. Place-based NGOs and grassroots initiatives helped create alliances with local communities, necessary to legitimize the claims of activists (Sander, 2016), a task that has been more difficult in Lusatia given greater local support for the coal industry and less presence of civil society organizations (see also Morton & Müller, 2016). The production of specific places as national symbols of the anti-coal movement has been a powerful force of general devaluation (cf. Gailing, 2019). One of the most notorious cases is the Hambach Forest, where activists have protested against the expansion of one of RWE’s lignite mines since 2012, a conflict that escalated in 2018 (Brock & Dunlap, 2018). This forest represented “a symbol of the phase-out of lignite”[32] (Liersch & Stegmaier, 2022). The dispute surrounding the expansion of the mine strongly influenced discussions in the Coal Commission[33] (Mohr & Smits, 2022). However, the case’s overwhelming symbolic role also limited the devaluation of other lignite operations by reducing attention on other villages at risk that, in contrast to the Hambach Forest, were not protected by the Coal Exit Law. About this, two members of the Commission observed:

> With this insistence on always pushing Hambach Forest to the fore, it didn't do justice to the magnitude of the task” / “I also tried very hard to keep the issue [of the villages at risk of displacement] on the agenda, which was only more difficult because the tens of thousands of people demonstrated at the Hambach Forest and not in the villages.[34]

[32] Member CC, November 10, 2020.
[33] Member CC, December 7, 2020b.
[34] Member CC, December 7, 2020b; Member CC, December 2, 2020.

Local embeddedness has not been the only relevant scalar strategy for the anti-coal network. Beyond the local legal strategies described above, other spatial legal strategies have also been key. In terms of litigation, constitutional climate complaints at the national level are increasingly important, including the one that resulted in a Federal Constitutional Court ruling in 2021, ruling the 2019's Federal Climate Change Act as partially unconstitutional. This landmark decision does not directly devalue coal but forces the government to strengthen decarbonization measures, promoting general devaluation.[35] At the EU level, lobbying, normally in cooperation with EU environmental organizations, promoted regulations that have made coal investments more expensive (e.g., strengthening the EU ETS, the Industrial Emission Directive, and the EU climate targets),[36] fostering the devaluation of coal by bypassing the national scale.[37] "That's how indirectly our work can then influence the national level," an environmental lawyer observed.[38] Legal and lobbying strategies are important devaluation forces at the *Länder* scale, the jurisdictional scale where mining extension, expropriation, and nature conservation issues are defined. Successful examples of legal and lobby strategies at this level include the case of Pödelwitz, a village in Saxony under threat of demolition by the expansion of a MIBRAG lignite mine. Thirty years of political pressure led to Saxony's minister announcing the protection of the village at the start of 2021.[39] However, this has not been the case for many other villages.

[35] Legal expert, July 26, 2021.
[36] NGO representative, June 14, 2021; Energy politics expert, August 23, 2021.
[37] Energy politics expert, August 23, 2021.
[38] Legal expert, July 9, 2021.
[39] NGO representative June 14, 2021.

Resisting devaluation

Pro-coal national networks have been central spatial formations in the resistance against coal devaluation: networks of unions, coal companies, energy intensive industries, and politicians. These networks have been able to build strong coalitions to influence policy decisions at the *Länder* and national scales since at least the 1950s (Brauers et al., 2020; Leipprand & Flachsland, 2018; for more details on the spatialities of the German coal lobby see Gürtler et al. 2021). Beyond the spatial political strategies, resistance to coal devaluation has also been based on spatialized market dynamics. Market integration from the national to the EU level not only provided a key source of devaluation but also a space to scale up domestic devaluation pressures created by renewables through an increase in power exports. Germany has been a net exporter of electricity since 2003 and became the world's largest exporter in 2009 (OEC, 2021). As an expert in EU electricity trade explains, "as soon as you open borders for electricity, then it just makes so much sense for Germany to be a net exporter because of the cheapness of lignite."[40]

This networked character of the EU's grid has also been present in spatial representations used in narratives to resist coal devaluation, especially by energy-intensive industries. They have accentuated, for example, the risks of carbon leakages either by an increase in coal-fired electricity imports or by the liberation for other EU countries of carbon allowances not used in Germany.[41] The pro-coal industrial sector has also raised concerns about the grid operation capacities of other European countries: "they don't trust French capacity."[42] This is related to the

[40] Electricity trade expert, April 13, 2021.
[41] Energy expert, June 19, 2019.
[42] Electricity trade expert, April 13, 2021.

fact that more integration in the physical network means that disruptions in one node can impact the whole network:

> Interdependence has grown historically. Some people say this is the main guarantee for peace in Europe. This is not a theory. Seven or eight years ago, there was a huge blackout for almost 24 hours, a catastrophe and it was trigged by a tree that cut a line in Switzerland (…) This has been used in the political arena as a populistic way of making the case against a coal phase-out.[43]

Pro-coal networks have engaged with place-based forms of resistance reflecting the concerns of residents in coal regions (many of whom are also coal workers)[44] (Markard et al., 2021), due to the role the industry plays in local jobs, corporate taxes, social investments, traditions, and identities (Brauers et al., 2020; Kalt, 2021; Leipprand & Flachsland, 2018; Morton & Müller, 2016). In Western Germany, where the main shareholders of the RWE lignite company are municipalities (15% in 2021) (Bathke, 2021), local governments and communities are closely tied to its interests. In the lignite regions of Eastern Germany, a more important source of resistance is a sense of devalued place related to economic decline (Belina, 2020; Gürtler, & Herberg, 2021). As a member of the SPD explains:

> In the Western parts of Germany, when coal production went down it was with a lot of gratitude to the workers. People got medals and stuff like this because they worked for creating a new Germany after the Second World War. And in the eastern part of

[43] Energy expert, August 18, 2021.
[44] In 2021, around 20,000 people worked directly in the German coal industry.

> Germany, you not only had the break in 1990, but you also have the break now, and since there's no such tradition here, it is like OK, your job is gone. Goodbye.[45]

This narrative, common in Eastern German coal regions, highlights the geohistorical and relational character of a devalued sense of place, which is associated not only with the level of concomitant devaluation, but also with the contrast of how in a similar process in the Ruhr area before, the state prevented larger impacts. Another dimension of this relationality is the fact that many current workers in the lignite sector have better working conditions than much of the rest of the population in lignite-producing regions, making the risk of having to change jobs more impactful. This risk can be especially felt by the minority of younger coal workers or those who have recently began working in the industry, both groups of whom have recently been trained. This contrast is evident given declining working conditions in Germany since the 2000s (Belina, 2013; Kalt, 2021). Given the good retirement conditions for coal workers, the concern of local residents refers to the concomitant impacts for people not directly employed in the industry as well as to the future of younger generations in the region (Bose et al., 2020). Many of these problems are accentuated in Eastern Germany, where a lack of skilled workers in a context of higher rurality and lower economic dynamism creates economic challenges (Miggelbrink, 2020). In this context, political populism has gained popularity in eastern coal regions, with pro-coal narratives common in the right-wing populist Alternative für Deutschland party (AfD).[46]

With less political power nationally than the traditional pro-coal network, representatives of AfD have used more radical anti-coal phase-out narratives in their political campaigns across

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[45] Representative political foundation, July 6, 2021.

[46] For a dialectic interpretation of the role of urban-rural relations in the success of AfD, see Förtner et al. (2021).

Germany, and especially through digital social networks (Matlach & Janulewicz, 2021). Although these two pro-coal networks do not formally cooperate, given substantial political differences, there have been sporadic and implicit forms of collaboration. For example, members of the SPD and CDU in Brandenburg aligned with AfD against protests by the activist group Ende Gelände, arguing that these activists could create individual devaluation of fixed capital through sabotage (DerTagesspiegel, 2019). A more implicit collaboration among coal workers, members of trade unions (IGBCE and Verdi), and the SPD and CDU, was seen in demonstrations in NRW against protests in the Hambach Forest in 2018 (Rose, 2018). Both networks have implicitly cooperated to avoid stronger decarbonization policies. Moreover, although the coal workforce seems to show low levels of support for AfD, news of members of coal unions starting to vote for (Plück, 2017) and convert to AfD (Klute, 2016) began to appear in the mid-2010s. In this context, unions warn against the risks of AfD gaining power from stronger coal phase-out policies as well as of negative local impacts represented important narratives to resist devaluation.[47]

Regulating devaluation: network governance for a national fix

The emergence of a national arrangement to deal with the increasingly prominent political issue of the future of coal, through the formation of the Coal Commission and the enactment of the Coal Exit Law, has to do with different aspects of the German political economy. First, it is related to the role of the national state in regulating individual devaluation in times of oversupply. Like the decommissioning premiums that started in the 1960s, the Coal Exit Law, with the auctioning system for coal-fired stations, provided a rapid subsidized devaluation of

[47] Union member, May 30, 2022.

individual capital to improve profitability (if only temporarily) for the coal and power sectors in general.[48] Abundant compensations for lignite companies provided by the Coal Exit Law also reproduce the longer role of the German state subsidizing devaluation. Second, a national "fix," in the regulationist sense of an institutional response to address a crisis of accumulation as well as legitimacy crisis (Jessop, 2006), is justified, given the importance of the national level to ensuring energy security.[49] This means that a coordinated national decision, based on the technical needs of the integrated German grid, is fundamental to ensuring security of supply. The relevance of the Federal Network Agency (FNA), the national regulatory body for electricity, in deciding when decommissioning plans are acceptable or not is also illustrative of this. For example, the city of Munich created its own exit plan after a referendum in 2017 resulted in a majority vote (60.2%) for a phase-out by 2022. However, the FNA overruled this decision, given consideration to high electricity demand from industrial agglomerations in the south, already affected by supply concerns due to the fact that renewables are concentrated in the north, as well as the lack of sufficient transmission capacity. Similar bans are a potential risk for phase-out plans in other cities (Straw, 2019).

The emergence of a national coal exit plan also responded to more conjunctural reasons. The double crisis of legitimation faced by the federal government, related to lower environmental credibility and the increasing popularity of the AfD, especially in Eastern Germany, concerned the ruling parties, especially before the 2019 elections in Brandenburg and Saxony.[50] A national response based on the Coal Commission as a consensual strategy was key in this regard. In the

[48] Energy expert, June 7, 2019.
[49] NGO representative, February 18, 2022.
[50] At the end, the AfD got 23.5% in Brandenburg (23 seats) and 27.5% in Saxony (38 seats), 11.3% and 17.7% more than in the previous election, respectively.

end, most of the Commission's deliberations focused on the issue of structural change in coal regions, and the Coal Exit Law primarily represented a mechanism to provide a preventive subsidy for devaluation rather than an agenda in line with the Paris Agreement (Furnaro, 2022). The so-called "trauma" of lignite devaluation in the 1990s was a regular topic for the Commission, and the need for a more active state was widely shared by its members: "this should not be repeated;"[51] "It was clear: [the state] must never again act as it did then."[52] The coal exit agreement, based on abundant[53] anticipatory compensations for coal regions, shows that the equalizing (redistributive) spatial role of the German state is still in place to improve legitimacy. In this context, field trips of the Commission to lignite regions represented a local re-embeddedness strategy:

> the field trips had an important function in themselves, namely that the Commission went to the coalfields to show the flag, to make it clear that we're talking about concrete issues here. We are talking about people in the coalfields, about the future of the coalfields, and about socially relevant issues[54]

A national process based on a multistakeholder consensus played an important role in the search for legitimacy. Central factors for this were the high consensus reached in the Commission

[51] Member CC, December 14, 2020.
[52] Member CC, December 3, 2020.
[53] In August 2019, Germany's federal cabinet passed the Structural Reinforcement Bill, which allocates 40 billion euros through 2038 to coal regions affected by the coal phase-out (2.2 billion per year, approximately): 26 billion euros through federal programs, and 14 billion euros for projects in NRW, Brandenburg, Saxony, and Saxony-Anhalt. For comparison, the total amount of payments to Eastern German States by the Solidarity Pact, one of the main financial tools used to economically support these states after reunification, was not substantially lower. The core component of the Solidarity Pact II, called Basked 1, gave to the three eastern coal states (Brandenburg, Saxony, and Saxony-Anhalt), from 2005 to 2019 (its last year of operation), 59.2 billion euros in total (Statista, 2012).
[54] Member CC, November 18, 2020.

(27/28 members with voting rights agreed on the final report, well beyond the required 2/3 quorum), the participation of several experts (as members and presenters), and an agreement based on the representation of stakeholders across the country (Gürtler et al., 2021). Extra-parliamentary negotiated political processes are common in Germany, reflecting its tradition of corporatist negotiating democracy. While tripartite negotiation systems were predominant during the coal crisis of the 1960s, expert committees and multistakeholder commissions became common from the end of the 1970s, in line with a global switch from government to governance (Czada, 2015). According to Czada (2015), independently of whether they succeed or fail, these commissions seek to outsource political decisions from those formally responsible in order to provide broader legitimacy for difficult issues that then only need to be ratified in the parliament.

Several interviewees observed that this was the case with the Coal Commission. Convening it meant that a hard decision was no longer the full responsibility of the government. Difficulties in addressing the coal issue were related to disputes among and within the government's coalition parties (Coggio & Gustafson, 2019). Some representatives from parties that supported a rapid coal phase-out at a national level took a more conservative position in coal *Länder*, especially in Eastern Germany,[55] including even the Green Party.[56] A national consensus could help avoid the re-politicization of the coal debate in the parliament:

> There were decisions that the politicians didn't want to make, but the point was that a consensus emerged throughout society and also provided the framework for legislation. So that was already helpful. (…) The more precise, the more helpful. I think that helps

[55] Energy politics expert, July 8, 2019a.
[56] NGO representative, June 22, 2021.

> the legislative process if the thorny issues are actually decided by the Commission, because if they're just passed on, then it just doesn't get done.[57]

Uneven spatial power relations shaped the discussion in the Commission. Although the heads of the coal *Länder* did not have the right to vote, several interviewees pointed out that they exerted excessive influence and that their interests were also over-represented by the protagonist participation of former prime ministers of coal regions as two of the four co-chairs of the Commission. Even though environmental NGOs represented powerful actors in the Commission, their power was disproportional relative to coal *Länder* and industrial and labor organizations with well-established lobbying and bargaining experience and power at the national scale. Only two small organizations represented villages affected by lignite mining. Both representatives, one of whom was the sole vote against the final compromise, had much less influence: "These two did not have any political weight. So if they say no there was not a big deal. If unions would have said no it would be a big deal, or if the environmental NGOs. The whole thing would have collapsed."[58] As Figure 8 shows, all the remaining private interest organizations represented in the Commission corresponded to national ones.

[57] Member CC, January 22, 2021.
[58] Energy expert, June 14, 2019.

Figure 8. Private interest organizations represented in the Coal Commission

Workers	*DGB:* Umbrella of 8 trade unions; 5.7 million workers	*Ver.di:* 2 million workers	*IGBCE:* 645000 workers	Interests also represented by 6 other members (9 in total)
Industries	*BDA:* 1.000.000 companies	*DIHK:* 120000 companies	*BDI:* 100000 companies	Interests also represented by 4 other members (7 in total)
Environmental organizations	*DNR:* Umbrella of 90 organizations; 5 million workers	*BUND:* 626000 members	*Greenpeace:* 595000 members (in Germany)	Interests also represented by 2 experts and 3 other members in the CC (8 in total)
Energy sector	*BDEW:* 1900 companies	*VKU:* 1500 companies		No represented by other members in the CC (2 in total)
Villages affected by lignite mining	*Buirer für Buir (Rhineland):* 100 members	*Grüne Zukunft Welzow (Lusatia):* Unknown		Interests partially represented by environmental interests in the CC (10 in total)

Source: the author

Several opportunities for re-politicization have been opened after the Commission, especially given the non-Paris aligned phase-out date. Moreover, the Coal Exit Law did not incorporate some of the main contributions of the anti-coal sector to the Commission's agreement: a linear phase-out, the ban on the new coal-fired station Datteln 4, and the annulment of the Garzweiler mine expansion (the final decision of the latter, however, being in charge of NRW). After the law was enacted, many organizations and research institutes switched to other topics. The Commission also intensified internal divisions in the anti-coal network, especially with the loss of the NGOs that signed the agreement from the more radical factions of the anti-coal social movement. Irrespective of whether the double legitimation crisis was resolved (the political rise of the AfD stalled, but the CDU's bad results in the 2021 elections left it out of the federal government), the consensus reached limited the possibilities for further regulations to accelerate the coal exit. The Coal Exit Law restricts the option of amendment without additional financial compensation for companies. However, it does not limit the possibility of including a national minimum price of carbon to improve the performance of the EU ETS for a phase-out by 2030.[59] This would correspond to the required date to be in line with the Paris Agreement, the stricter decarbonization goals defined by the EU Green Deal, and the April 2021 decision of the Federal Constitutional Court, as well as the decision of the Federal Constitutional Court in April 2021. 2030 is also part of the compromise of the Greens-Liberals-SPD coalition established in 2021; if effective, it would add a subsequent market-mediated devaluation force to the equation (Litz et al., 2021).[60]

4.6. Discussion

This case study contributes to the geographic literature on energy transitions by showing some of the dimensions of coal devaluation, a necessary but less studied aspect of the energy transition by this scholarship (Bridge, 2018). In contrast to what has been described as the spatiality of capital

[59] Energy expert, May 31, 2021.

[60] It is important to acknowledge how dynamic energy markets are and how this can deeply affect Germany's coal exit policy. This publication was submitted before the emergence of the energy crisis of 2022, which has put into question the possibility of reaching the 2030 goal.

devaluation in general, which is always place-specific but whose locations are anarchically defined (Harvey, 1982), the German case shows that the geographies of coal devaluation can be better understood from the perspective of the moral devaluation of coal (Furnaro, 2021). Through this lens, the location of devalued fixed capital in the coal sector depends on a combination of anarchic geographies of market competition, the territorial demarcations of regulations affecting energy markets, and the spatial strategies of anti-coal coalitions and of pro-coal sector.

The German case also shows the importance of differentiating the devaluation of upstream and downstream fixed capital in the coal sector to better understand these geographies. The unique types of regulations that characterize electricity capital (Luke & Huber, 2022) and their relevance in terms of energy security makes electricity capital devaluation difficult by pure market forces, and in some cases, even by regional phase-out policies that can be banned by national regulatory bodies. Different forms of spatial embeddedness of electricity systems (Dahlmann et al., 2016) according to, for example, the use of different types of coal, with lignite creating localized vertical integration, should also be considered to better understand at what scales devaluation is more effectively promoted and resisted.

The description of the spatial strategies to promote and resist devaluation in Germany, such as multiscalar lobbying practices or local embeddedness by the pro-coal sector, adds more examples to the literature of re-scaling and other spatial strategies to promote and resist the energy transition (Bridge, 2018), especially by emphasizing the less recognized role of spatial narratives and imaginations of the past, present, and future (see also Kuchler and Bridge, 2018).

More needs to be said about the differences between these strategies when comparing coal devaluation with the resistance and promotion of renewables.

Not all countries will organize a national, politically negotiated, and generously subsidized coal exit process as Germany is doing. The geographies of the German coal exit shed some light on understanding why this is the case, considering the peculiarities of the country's political geography requiring cooperation from major parties at a national scale, of its spatial repertoire of crisis management practices where devaluation costs tend to be transferred to the national state, and of the relevance of national networks of labor and business lobby in regulating industrial relations.

4.7. Conclusions

This paper contributes to the literature on the geographies of low-carbon energy transitions by analyzing the geographies of the German coal phase-out. This case shows that the geographies of phasing out fossil fuels can be better understood by looking at the spatialities of moral devaluation. From this perspective, some of the most important spatial forces of coal devaluation in Germany have been associated with the introduction of competition by transformations in the spatial organization of energy markets as networks of commodity and commercial exchange. This was the case with the international liberalization of fossil fuel markets after World War II (especially harmful for the hard coal industry), the territorialization of Germany's market economy and energy system after reunification (especially harmful for lignite), and, more recently, the scaling up of the physical and commercial electricity network from the national to the EU level (especially harmful for coal-fired electricity). Territorial regulations have been central in promoting these transformations, with the liberalization of coal prices by the European

Coal and Steel Community, the privatization of eastern lignite companies after reunification, and the creation of stricter competition rules at the EU level, respectively. Territorially based environmental regulations, especially the reformulated EU ETS, add a new element to the regulation of the energy market that became a key force of devaluation domestically.

The role of the state in addressing these forces of devaluation varies in line with broader political-economic tendencies, showing the importance of understanding the spatial regulation of fossil fuels in the context of the changing spatialities of state power. While a developmentalist model of regulating devaluation is key to explaining the role of the West German state in subsidizing coal regions in the 1960s, the rupture with the equalizing state in the 1990s helps explain (at least in part) a less contained and subsidized devaluation of lignite in East Germany by the state. Without looking at these spatial trajectories, it is hard to fully grasp the legitimacy crisis that unfolded in the late 2010s. The crisis for Germany's reputation as a climate leader, is associated with the multiple spatialities of the forces of devaluation promoted by anti-coal networks. A double legitimacy crisis created by the incapacity of the state to deal with two elements of coal devaluation on time, its concomitant costs locally (past and expected), and the need to accelerate it to meet its climate targets, made a national fix based on network governance the preferred approach to restoring legitimacy (independently of whether or not it was successful).

Spatial strategies to promote, resist, and regulate devaluation are central components of the phase-out of fossil fuels. In Germany, the national anti-coal network embedded itself in coal-producing regions and litigated and influenced political and regulatory processes at different scales. The spatial strategies of this network have promoted individual and general devaluation, the latter especially by the production of places as national symbols. On the other side, pro-coal networks influenced these different scales to resist devaluation for years. Coal devaluation has also been resisted through spatial market strategies, as well as through spatial narratives.

More empirical research to understand the geographies of devaluation is needed. This includes comparative analyses to show what spatial strategies are more effective in promoting and resisting devaluation in countries where different political-economic relations predominate. Case studies that improve understanding of the geographies of devaluation among different fossil fuels and fractions of the energy sector (upstream, midstream, and downstream) are also important to avoid hiding these differences under the general devaluation umbrella. Finally, the geographies of processes of revaluation should be examined carefully, including the ways that fixed capital in German coal regions is being repurposed, processes that should be understood in connection to, rather than as fully independent of, devaluation, as they can represent important path-dependent strategies to deal with devaluation impacts.

CHAPTER 5. CONCLUSIONS

5.1. The devaluation challenge

In the context of the climate crisis, fossil fuel-producing countries face the complex challenge of having to prematurely shut down a portion of their physical infrastructure associated with the extraction and production of fossil fuel energies, which is central for the functioning of their economies and deeply embedded in their social fabrics. By analyzing the political economy of the German coal phase-out, this dissertation showed that the challenge of accelerating a low-carbon energy transition is not only about the regulatory arrangements through which renewable energies are promoted and incorporated in the energy system, which is the most well-known aspect of the *Energiewende* and the most emphasized subject of study by energy geographers and other energy scholars in the social sciences. A genuine energy transition is also – from the perspective of decarbonization, more importantly – about the different processes through which fixed capital in the fossil fuel sector stops operating.

This includes a broad range of special regulatory practices, such as those implemented in the German coal exit plan: contractual arrangements with owners and operators of energy infrastructure for a planned shutdown of infrastructure, auctions for the competitive distribution of decommissioning premiums, and reserve systems for leaving energy infrastructure in temporary or permanent standby given energy security purposes. These special regulations are combined with more everyday regulatory practices that define the pace and conditions for the early shutdown of energy infrastructure, such as power plant disconnection permits and procedures, involuntary early retirement policies for workers, and bankruptcy laws, among many others. This dissertation sought to accentuate the relevance of these types of practices in the study of the political economy of energy transitions. Implementations, discussions, and reforms of these and related regulations will become central practices in the future governance of our fossil energy past, if current carbon-intensive energy regimes effectively become past ones at the rate required to avoid the worst effects of climate change.

This dissertation also showed that theories of capital and fixed capital devaluation offer a useful lens to analyze the phase-out of fossil fuels in connection with the functioning of capitalist economies. The challenge of prematurely shutting down energy infrastructure is highlighted by the notion of fixed capital devaluation, i.e., the early loss or destruction of value of still-operative infrastructure. Capitalist economies face the issue and risk of fixed capital devaluation daily, including energy infrastructure, as something inherent to capitalist development. This includes a range of cases of devaluation, from the mundane malfunctioning of infrastructure and machinery to the permanent process of devaluation by competition (Schumpeter's [1950] "creative destruction," or Smith's [2017] "progressive devaluation"), as well as the more or less systematic devaluation by destruction seen during wars and economic or oversupply crises. Therefore, looking at the arsenal of tools that capitalist economies already have in place to deal with fixed capital devaluation is instructive to understanding the ways through which the devaluation of fossil fuels is and can be promoted, resisted, and managed today. As the German case shows, however, existing tools and pathways are always open to being transformed.

When using the devaluation lens, maintaining balance between routine and new ways of promoting, resisting, and managing devaluation is crucial, not only because capitalist devaluation has always involved unexpected forms and outcomes, but also because the climate crisis is a relatively new scenario with novel factors in play. The conundrum faced today is twofold. First, the ecological conditions of capitalism and its profitability, which is increasingly challenged by capitalism's own effects (O'Connor's [1996] second contradiction). Second, fossil fuel-dependent systems, the lifeblood of existing industrial economies (at least as known up until now) (Malm, 2016; McCarthy, 2015), are increasingly put into question by the global political consensus reinforced by the climate movement. This double conundrum involves a new scenario that goes beyond the conditions defining most common forces and mechanisms of fixed capital devaluation.

In this context, echoing Marx's usage of the notion of *moralische* (Marx, 1992a:528) to distinguish socially-driven forms of fixed capital devaluation (especially those related to market competition) from *more* technologically driven ones (especially those caused by failure, overuse, or lack of use), this dissertation introduced the notion of moral devaluation of fossil fuels. The moral devaluation framework presented in Section 2 served as a heuristic approach to capture the role that more-than-technological and more-than-market drivers, including those associated with the pressures exerted by the climate movement, are playing in accelerating the premature devaluation of fossil fuel infrastructure. The moral devaluation framework also facilitates the analysis of political relations beyond the market, by showing the role of socioenvironmental pressures, private and public institutions, legal frameworks, and common narratives and interpretations in driving and shaping how and when fossil fuels are phased out. Moreover, by keeping and emphasizing its connections with broader rules and tendencies of capital devaluation, the notion of moral devaluation forces us to see the political conjunctures that define the phase-out of fossil fuels in connection with the functioning of capitalist development. This framework allowed an interpretation of the political economy of the German coal phase-out as a relational process, where political and economic factors were presented in constant interaction, tension, and movement, and where the discursive work of separating these factors was described as an internal aspect of this process.

5.2. From a "green" frontrunner to a relative latecomer

One of my initial intentions with this dissertation was to generate lessons from the German case on how other fossil fuel-producing countries can accelerate phase-out decisions. This goal, however, changed during the early stages of the research process. The historical evidence suggesting that an important portion of the German coal industry has been facing a structural economic crisis since the 1960s, during which time devaluation has been systematically resisted through different direct and indirect subsidies (Oei et al., 2020), made me reconsider my initial questions. From the conditions that allowed Germany to agree to an early phase-out of production, the question about what conditions allowed the survival of this industry despite the pressures of progressive devaluation given lower costs of alternative fuels and technologies, gained more relevance. After preliminary fieldwork conducted in 2019, weeks after the Coal Commission published its final recommendations for a national coal phase-out process, including the non-Paris Agreement-aligned year of 2038 as the coal exit date agreed upon, it became evident that the German coal phase-out policy was not a climate policy that would accelerate the decarbonization of the country's energy sector. Suspicions about this policy representing a huge bailout for polluting coal companies, many of which were struggling economically, especially since the increase in the EU ETS prices in the late 2010s, was strongly present in the public opinion as well as in the view of many of this study's interviewees, and was an additional factor that made me reconsider my initial interest. The question of how important the economic crisis faced by the coal industry was in defining the timing and content of the coal exit agreement gained importance.

Chapter 3 of this dissertation indicates that, rather than a green frontrunner, a reputation that Germany has proudly promoted for itself internationally in recent decades, the country has been a relative latecomer in terms of declining coal production in line with the Paris Agreement. This conclusion seems counterintuitive given that Germany is an important coal producer and one of the only ones with a legally binding exit plan. However, the German coal phase-out is fairly late when considering the level of subsidies that the country has implemented to keep the industry alive, as well as the amount of climate pressures that different organizations and social movements have exerted since at least the 1990s. The coal exit process is also late when compared with the case of the United Kingdom, one of the main industrialized countries in Europe, and also an important historical producer of coal. The United Kingdom has been able to rapidly phase out coal production with little to no subsidies to the coal industry, but rather through the implementation of a carbon tax in 2013 that rapidly increased in the following years, an approach that was always blocked by the pro-coal sector in Germany (Brauers et al., 2020). This tax, as a market-mediated devaluation force, was a central driver in the decline in production in the United Kingdom's liberal market economy, where the power or coal unions were strongly limited since the 1980s. In contrast, in Germany, coal unions and their influential networks have been successful in resisting the devaluation of the industry for decades.

However, Germany's international leadership in the development and incorporation of renewable energies cannot be negated by its dirtier coal history. One of the goals of this dissertation was to make sense of both aspects of the German *Energiewende* as a whole. Understanding the devaluation challenge as a different but related process to the expansion of renewable energies was useful in this regard. For this, analyzing how different political economies (e.g., Germany's coordinated capitalism vs. the United Kingdom's liberal market economy) involve different styles of dealing with value creation in the renewable energy sector as well as devaluation in the fossil fuel sector, provided a theoretical approach to make this connection. In Germany, as most likely in any other fossil fuel-rich country, committing new investments in the renewable energy sector is a politically easier task than organizing the premature shutdown of fossil fuel investments. In this sense, it is not surprising that the strong climate and environmental movements in Germany have been more successful in promoting the development of renewable energies than the phase-out of coal. Both aspects of the *Energiewende* are of course connected, as cheaper and more abundant renewable energies were a necessary condition for the coal phase-out to be a technically and economically feasible plan. However, far from sufficient, the prolonged coexistence of both sources of energy in Germany teaches us about the limits of seeing renewable energies as inherently "green" (decarbonization) projects, especially when political pressures are in place to limit their capacity to progressively devalue fossil fuel energy production.

The relational political economy of the German coal phase-out described in Chapter 3 showed the specific ways through which political and market relations in combination defined the possibilities and contours of the exit agreement. The German case illustrates how even in economies where so-called coordinated capitalist relations predominate, market forces, as mediators of environmental regulations such as the EU ETS and also by themselves (based on the rules of price competition), can play a central role in defining the timing of coal exit agreements. This means that rather than taking for granted that coal phase-out processes will always be faster in liberalized market economies, the role that political forces can play in delaying the process can always take alternative forms, though not necessarily less relevant in delaying the process. In the United States, for example, where coal power production has been in a sharp decline since 2010, mostly because of market forces (cheaper natural gas and renewables) (IEA, 2022b), political forces have been successful in impeding the emergence (by now) of a national coal exit agreement, despite mounting national and international pressures asking for such a policy (Plumer and Friedman, 2021).

The German case also shows the relevance of problematizing the popular market- vs. policy-driven distinction used to describe coal phase-out processes (e.g., Rentier et al., 2019, Drake and York, 2021), which is many times difficult to establish. For example: is the increase in prices of the EU ETS, especially after its strong reforming, a market- or policy-based driver? Are cheaper renewables, especially after decades of public support, a market- or policy-driven force? Are coal exit policies implemented as a response to the loss of profitability for coal operators a market- or policy-driven process?

The German case also provides some examples of how this distinction is used by different actors to justify certain decisions and policy pathways, such as higher compensations for companies affected by what is considered a purely policy-driven coal phase-out. In this context, problematizing doesn't necessarily mean dissolving the policy vs. market distinction. A better understanding of this distinction is increasingly relevant as the interpretation of large-scale phase-out decisions representing or allowing coal companies bailouts is gaining prominence in other contexts such as South Africa (Shankleman et al., 2022), and in some cases of plant retirements in the United States (Glustrom, 2021). The German case, in which utility companies have been able to use financial reports in their favor to claim higher compensation payments, shows the importance of timely and transparent processes of financial disclosure and accounting practices that can help more precisely define the economic conditions under which exit decisions are made as key to avoiding ending up subsidizing polluting fossil fuel companies and not necessarily accelerating their phase-out.

5.3. Geographies of phasing out fossil fuels

Although the national character of the coal exit agreement and law enacted in Germany is one of the main spatial features of this process, a deeper look at the geographies of the German coal phase-out showed that global and local factors were also crucial. Chapter 4 of this dissertation showed the central role of the local scale to resist the devaluation of coal as well as to promote it through different material and symbolic practices that rescaled the coal conflict to the national level. This section also showed how global and international forces, through market pressures as well as increasing political and regulatory ones (the latter especially at the EU level) deeply influenced and promoted the phasing out of German coal.

One major contribution of this dissertation is a detailed understanding of how the spatialities of multiple devaluation crises and their regulatory fixes unfold in a specific context. Chapter 3 described the double crisis of legitimation in Germany, related to the crisis faced by the federal government for its incapability to meet its climate compromises on the one hand, and its political crisis associated with the rapid decrease in public support to the ruling parties in many regions in Eastern Germany, including lignite regions, on the other hand. Both legitimation crises put the idea of a coal exit at the center of the German political agenda around 2018, something unimaginable only a few years earlier. Germany's political geography was central to understanding this double crisis, with elections at the state (*Länder*) levels playing a key (although not unique) role in defining the timing for the emergence of a national fix and a coal exit agreement based on strong financial support for coal regions.

As Chapter 4 showed, the spatialities of Germany's industrial relations and existing practices to regulate the risks and impacts of fixed capital devaluation were equally important to understanding the geographies of the coal phase-out. Devaluation crises, especially in the coal sector, have been common since the 1960s, and their implications were central factors to understanding the recent coal exit agreement. The relevance of trade unions organized at the national level as a key negotiating force, also with strong ties at the *Länder* and more local levels, was central for the development of a multi-stakeholder national commission that was able to reach a better deal for coal companies, workers, and regions than for the environmental organizations they represented. In this context, a national fix based on a consensual multi-stakeholder and expert commission showed the relevance of considering the scales at which these mechanisms are enacted as an important factor in defining the commission's depoliticization function and capacity.

It is probable that not all coal-producing countries will create nationally organized coal exit plans and laws as Germany is doing. This dissertation showed that this is not necessarily positive or negative in terms of accelerating decarbonization, but rather that fossil fuel exit policies need to be analyzed case-by-case, considering the timing of existing exit plans and the pressures that other forces, especially market-based ones, would have exerted anyway. Independent of Germany's Coal Exit Law decarbonization role, most of the interviewees of this project argued that the German planned and consensual approach seems more suitable in terms of ensuring a just transition for workers and coal communities, though this isn't always necessarily the case. Germany's corporatist industrial "tool kits" (Granovetter, 2017), and its existing repertoire of actions to resist and regulate devaluation are helpful to consider when trying to make sense of the emergence of a national fix to the double legitimation crisis. Detailed accounts of national and regional political economies and political geographies are key to better grasping why certain approaches to dealing with the devaluation challenge can be more suitable in some contexts than others, and can also help better visualize strategies for eliciting change, accelerating decarbonization, and avoiding expensive bailouts to polluting companies.

Many other aspects of the political geographies of fossil fuel-producing countries need to be considered to understand different preferences in terms of governance tools employed to regulate the devaluation of coal. For example, Germany's federal organization and civil law system, which give *Länder* governments important veto power and require greater levels of coordination and consensus (Casper, 2001), are collaborative dimensions of its coordinated mode of economic governance, and were also important to understanding the ways that devaluation is regulated. These factors were also especially important to understanding the relevance of the emergence of a national scale fix to address the devaluation and double legitimation crises that constituted important drivers of the Coal Exit Law.

The German case also demonstrates the relevance of considering the historical geographies of coal regions and countries when analyzing the current politics of coal. Very different crises of devaluation experienced in the 1960s in Western coal regions and 1990s in Eastern lignite regions are still important, not only in the memory of policymakers and residents of these places, but also in the institutionalized practices and organizations dealing with the regulation of coal.

Perceptions on how both crises were differently addressed by the German state, with the strong support provided in Western coal regions and a sense of abandonment in Eastern ones, deeply shaped the current exit agreement. They were key in discussions about whether and how a coal exit policy should be implemented. In the context of increasing critiques against Germany’s public and long-term financial support to the coal industry from the environmental movement, as well as popular claims against the public abandonment of Eastern states, including its lignite regions, memories of past devaluation crises were a crucial component in the coal exit debate.

5.4. Limitations of this project

One of the main limitations for adequately responding to the research questions that motivated this project is the lack of available public data about the financial situation of coal companies. Limited financial disclosure from fossil fuel companies is an extended problem today that challenges current capacities to assess the reasons behind divestment and shutdown decisions everywhere. This complicated this study by limiting the ability to respond to the question of to what degree the economic crisis facing several utility companies operating coal-fired stations was an important reason for them to sit at the negotiation table to define a coal exit date based on high compensation payments. Economic assessments developed by research centers and organizations experts on the topic (ClientEarth 2020a; 2020b; Brown, 2020) were cited in this dissertation to support the common claim among many interviewees that a devaluation crisis was in fact key to achieving the political momentum needed for a coal exit agreement to emerge. However, as some of these experts also pointed out, determining the economic viability of coal power stations is commonly based on a complex range of factors that make a general assessment of their economic situation difficult. Moreover, the tendency of fossil fuel companies to inflate financial statements, especially on the verge of a possible compensation discussion, also limited the possibility of clear assessments of their economic situation.

Conducting qualitative fieldwork during the Covid-19 pandemic also posed special challenges that limited my ability to meet some of the goals of the original project, and possibly affected some of the conclusions presented here. Although conducting virtual interviews was favorable, as they facilitated my ability to meet with people located in different cities across Germany, this also limited my access to narratives from actors less accustomed to employing technologies for video calls. Although I readapted the design of my project to give it a more national-level perspective, based on a major reliance on "expert" voices, I am aware that the interpretations provided by the interviews conducted do not capture with the same level of depth the opinions of key actors in the coal exit debate in Germany, especially residents from lignite regions, as well as coal workers, who were less represented in the final sample than energy experts and NGO representatives. Limitations to conducting more interviews with actors from the pro-coal sector (possibly another common problem related to the nature of this study) mean that some of their perspectives and interpretations could have been neglected in this dissertation. Most of the interviews conducted with these types of actors highlighted their official character, in the sense that their responses were not very different from ideas that are already publicly available in the annual reports or press releases from the organizations they represent. This limited my capacity to see how the more daily politics and internal conflicts within the pro-coal sector could have played a role in the defining of the coal exit agreement, something important for future research on this topic that treats seriously the idea that the pro- vs. anti-coal distinction is full of contradictions and internal differences.

5.4. 2022: War in Ukraine and a new energy crisis

Most of the fieldwork and analysis conducted for this project took place before Russia's invasion of Ukraine and the energy crisis that followed, which deeply impacted Germany. At the moment of writing (November 2022), Germany hasn't modified the Coal Exit Law, and the current *Ampel* government coalition hasn't expressed any intentions to expand the use of coal beyond 2038. Moreover, the government hasn't retracted its compromise to accelerate this exit date to 2030. However, emergency legislation to temporarily reactive mothballed coal-fired stations was passed in July 2022, a direct result of the shortages in gas supply (Connolly, 2022). Although the government has argued that this only represents a short-term crisis management tool, some voices are suggesting that the 2030 goal may not be realistic anymore, at least without abundant additional compensations and policy efforts (Egerer et al., 2022).

The challenge that the crisis supposes for Germany's energy security clearly represents an important factor in reducing coal devaluation pressures, at least in the short term. However, this crisis is also showing the need to reduce dependence on hard coal and gas imports for energy generation, especially through the role of renewables, memorably referred to as "the energies of freedom" by the finance minister in the context of the 2022 crisis. This explains why the federal government has moved forward by 15 years the 100% renewable energy target (from 2050 to 2035). Therefore, the energy crisis is reducing the market devaluation pressures against hard coal and lignite, while at the same time increasing the moral devaluation of hard coal through the energy security concerns associated with import dependence, and of both hard coal and lignite through the vast new support given to renewables.

Although many interviewees highlighted the energy security risks of depending on Russia's gas, this was also seen as a secondary concern in the design of the coal exit. Chapter 3 showed the importance of cheap gas supply in driving the devaluation of coal during the 2010s. However, this chapter doesn't emphasize enough the important role that the *Energiewende* assigns to natural gas as a "bridge fuel" in the phase-out of coal. The Coal Exit Law assumed low natural gas prices in the medium term and a secure gas supply from Russia, especially through the role that the Nord Stream 2 pipeline through the Baltic Sea would have played in terms of energy security by providing direct access to this supply, skipping Ukraine soils, which were the gatekeeper to the European gas market. Therefore, the conditions for the devaluation of coal in Germany supposed the reproduction of a stable *Ostpolitik* (Eastern Policy) (Stent, 2022). Although this doesn't necessarily challenge the argument about the main drivers that explain the emergence of the Coal Exit Law presented in this dissertation, current events make it necessary to highlight this geopolitical dimension as a central condition for the future of the coal exit plan.

A clear indication of Germany's dependency on Russian gas was the astonishing lack, until November 2022, of any liquefied natural gas (LNG) terminal in the country that could help diversify supply. The relevance of the *Ostpolitik* in this dependency, as well as the vulnerability of Germany's energy policy manifested with the 2022 energy crisis, add to a previous argument sustained in this dissertation on the flexibility and fractures of Germany's long-term planned approach to energy devaluation. In other words, Germany's planned approach for a coal phase-out, so commonly associated with the German style of low-carbon energy policy, is far from stable. If we go beyond the policy moment that the design and enactment of the Coal Exit Law represented, and therefore avoid overemphasizing this policy moment, it is easier to appreciate the complex articulations between political and spatial factors driving and shaping the coal phase-out process, including the most contingent ones, which create instability and rupture in Germany's long-term approach to energy planning.

5.5. Future lines of inquiry

There are many relevant avenues for future research associated with this dissertation's questions and findings, three of which are worth mentioning in this concluding section to shed light on some of the implications of further developing a research agenda on the political economy of phasing out fossil fuels.

The phase-out of fossil fuels today is a normative goal as much as an empirical reality that is and will increasingly be seen, with the transformation of energy systems around the globe, and with it, the conditions for a variety of social relations built upon their functioning. Distributive questions should be at the center of the social research agenda on the fossil fuels phase-out from empirical and strategic perspectives. From an empirical viewpoint, this includes questions such as what types of actors (e.g., individual and institutional taxpayers and ratepayers) are financing fossil fuel exit policies or are left behind by compensation mechanisms (e.g., indirect or induced workers as well as the general working class and other impoverished groups not included in most just transition policies). More detailed accounts of the distributive dimensions of the German coal exit as well as other phase-out processes are needed, although following the money can be an extremely difficult, and in some cases, impossible, goal to accomplish. These empirical analyses can have important implications from a strategic perspective, by improving understanding of the mechanisms through which the financing of phase-out processes can accelerate decarbonization as well as unjust distribution of costs that different ways of financing can create.

A second key avenue for future research has to do with the political economy of revaluation processes. Revaluation is an inherent aspect of devaluation – however, it is beyond the scope of this study. This includes issues such as the role that possible forms of value creation through the reconversion of fossil fuel-fired power stations and sites of fossil fuel energy production are having in accelerating, delaying, and defining the rules of the phase-out of fossil fuels. Future research could engage with theories of capital devaluation and revaluation (as well as value in general), especially in relation to the energy sector, to better understand the role of certain forms of value creation in this phase-out. This approach seems particularly suitable to explore the case of green hydrogen investments, for example, as a real and imagined possibility for value creation through the reconversion of existing fossil fuel energy infrastructure, and assess its suitability to truly accelerate decarbonization.

Finally, emphasizing again the particularities of the German case is relevant to better understand its usefulness for exploring the specific character of fossil fuel devaluation challenges in different countries. Here, I'm specifically thinking of fossil fuel-rich countries in the Global South, where the possibilities of massive phase-out processes financed by the national state are highly restricted. More case studies from the Global South are needed to understand not only the challenges to accelerate the phase-out of fossil fuels in those contexts, but also the challenges that a rapid global phase-out in fossil fuel consumption can create (the transition risk problem; Bradley et al., 2018), is a central avenue for future research. This research agenda would benefit from more comparative approaches, i.e., North-North, South-South, and South-North. Given that the category of not only taxpayers but also ratepayers lose significance when analyzing the distributive dimensions of phasing out fossil fuels in many countries that are highly dependent on fossil fuel rents (normally imposing low tax burdens for citizens) and many times energy-poor (with low levels of reliable electricity access), more appropriate categories to study the distributive dimensions that really matter surrounding the phase-out of fossil fuel production in the Global South are urgently required.

APPENDIX

List of interviews[61]

N	Tag	Online/In Person
1	Member CC, October 21, 2020	Online
2	Member CC, September 9, 2020	Online
3	Member CC, November 10, 2020	Online
4	Member CC, November 11, 2020	Online
5	Member CC, November 18, 2020	Online
6	Member CC, November 23, 2020	Online
7	Member CC, November 26, 2020a	Online
8	Member CC, November 26, 2020b	Online
9	Member CC, December 2, 2020	Online
10	Member CC, December 3, 2020	Online
11	Member CC, December 7, 2020a	Online
12	Member CC, December 7, 2020b	Online
13	Member CC, December 9, 2020	Online
14	Member CC, December 14, 2020	Online
15	Member CC, December 22, 2020	Online
16	Member CC, January 15, 2021	Online
17	Member CC, January 22, 2021	Online
18	Energy expert, June 7, 2019	In-person (Berlin)
19	Energy expert, June 13, 2019	In-person (Berlin)
20	Energy expert, June 14, 2019	In-person (Berlin)
21	Energy expert, June 19, 2019	In-person (Berlin)
22	Energy politics expert, July 8, 2019a	In-person (Berlin)
23	Energy politics expert, July 8, 2019b	In-person (Berlin)
24	Energy expert, July 9, 2019	In-person (Berlin)
25	Energy labor expert, July 9, 2019	In-person (Berlin)
26	Environmental manager utility company, July 18, 2019	In-person (Berlin)
27	Member CC, July 23, 2019	In-person (Berlin)
28	Carbon markets expert, July 26, 2019	In-person (Berlin)
29	German politics expert, July 26, 2019	In-person (Berlin)
30	Member CC, July 31, 2019	In-person (Berlin)

[61] The first 17 interviews were conducted by members of the Coal Exit Group.

31	Representative trade union, August 15, 2019	In-person (Berlin)
32	Energy expert, September 31, 2019	In-person (Berlin)
33	Energy expert, January 18, 2021	Online
34	Energy expert, January 19, 2021	Online
35	Activist, February 11, 2021	Online
36	Electricity trade expert, April 13, 2021	Online
37	Member CC, April 21, 2021	Online
38	Energy labor expert, April 22, 2021	Online
39	Representative political foundation, April 22, 2021	Online
40	Energy politics expert, May 17, 2021	Online
41	Structural change expert, May 18, 2021	Online
42	Energy expert, May 31, 2021	Online
43	Energy geopolitics expert, June 2, 2021	Online
44	Representative renewable energy sector, June 3, 2021	Online
45	Representative public agency, June 4, 2021	In-person (Berlin)
46	NGO representative, June 8, 2021	Online
47	Structural change expert, June 10, 2021	Online
48	NGO representative, June 14, 2021	Online
49	NGO representative, June 22, 2021	Online
50	Structural change expert, June 30, 2021	Online
51	Representative political foundation, July 6, 2021	Online
52	NGO representative, July 8, 2021	Online
53	Legal expert, July 9, 2021	Online
54	NGO representative, July 9, 2021	Online
55	Energy politics expert, July 13, 2021	Online
56	NGO representative; ex-representative municipal utilities, July 14, 2021	Online
57	Representative public agency, July 15, 2021	Online
58	Carbon markets expert, July 16, 2021	Online
59	NGO representative, July 22, 2021	Online
60	Representative public agency, July 24, 2021	Online
61	Legal expert, July 26, 2021	Online
62	Representative utility sector, July 26, 2021	Online
63	Representative public agency, July 28, 2021a	Online
64	Representative public agency, July 28, 2021b	Online
65	Representative public agency, July 29, 2021	Online
66	Mining recultivation expert, July 29, 2021	Online
67	Representative public agency, August 10, 2021	Online
68	Mining recultivation expert, August 17, 2021	Online

69	Energy expert, August 18, 2021	In-person (Berlin)
70	Energy politics expert, August 23, 2021	Online
71	Energy politics expert, November 8, 2021	Online
72	NGO representative, February 18, 2022	Online
73	Utility sector representative, February 19, 2022	In-person (Berlin)
74	Energy intensive industries representative, March 10, 2022	Online
75	NGO representative, March 17, 2022	Online
76	Energy intensive industries representative, March 21, 2022	Online
77	Energy intensive industries representative, March 22, 2022	Online
78	Carbon markets expert, March 25, 2022	Online
79	Representative public agency, March 30, 2022	Online
80	Energy intensive industries representative, April 5, 2022	Online
81	Utility sector representative, April 11, 2022	Online
82	Industrial relations expert, April 11, 2022	Online
83	NGO representative, April 18, 2022	Online
84	Energy expert, April 23, 2022	In-person (Berlin)
85	Industrial relations expert, May 30, 2022	In-person (Leipzig)
86	Union member, May 30, 2022	In-person (Leipzig)
87	Expert in German politics, May 31, 2022	In-person (Leipzig)
88	Union member (a), May 31, 2022	In-person (Leipzig)
89	Union member (b), May 31, 2022	In-person (Leipzig)
90	Union member (c), May 31, 2022	In-person (Leipzig)

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