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En route to decarbonization: A periodisation of just transition in four carbon-intensive EU regions

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ABSTRACT

In 2019, the European Commission launched the Green Deal to achieve climate neutrality by 2050, with the decarbonization of energy sources as one of its pillars. However, decarbonization is proceeding unevenly and is creating significant disruption, especially for regions that are heavily dependent on coal cycle activities. We do not know exactly how, when and why regional actors switch from resisting decarbonization to more adaptive, and transformative decarbonization strategies, and how to provide support for this process. This paper examines how four EU carbon-intensive regions respond to increasing decarbonization pressures, and periodizes the energy transition process in four carbon-intensive European regions.

This work employs concepts from two strands of literature: phases of energy transition, and just transitions. For our analysis, we integrated two methods: interviews & focus groups, and national & regional press analysis. We could identify several 'periods' for each region's transition, characterized by different combinations and prevalence of resistance, adaptation, and transformation actions.

Our findings suggest that (i) regions that have a clear plan for workers' transitions with funding attached are at an advantage in progressing to further transition phases; (ii) when transition plans are subject to wide participation, the process appears smoother than with top-down processes; (iii) countries characterized by a less diversified power mix and a higher dependency on a single national resource tend to transition more slowly; (iv) regions that are faring economically better will not automatically be at an advantage in the transition if they have a powerful incumbent fossil industry.

1. Introduction

Coal was consumed in record amounts in 2022 (IEA, 2022), and consumption is failing to decline quickly enough to meet Paris Agreement 2 °C targets, (IPCC, 2022: 8) (Eurostat, 2023). In 2019, the European Green Deal was launched to achieve climate neutrality by 2050, with decarbonization as a pillar. However, despite a favourable regulatory framework, decarbonization across the EU is proceeding unevenly and is creating significant disruption, especially for regions that are heavily dependent on fossil fuel production and processing. This has caused a range of responses to decarbonization policy–many at least initially focused on resisting these changes, and others adapting to the new policy environment depending on the degree to which socioeconomic and institutional conditions have changed in response to decarbonization (Nacke et al., 2023). Drawing inspiration on two strands of academic literature centred on phases of energy transition and on just transitions, this paper examines how carbon-intensive regions cope with decarbonization pressures and maps these responses to different transition phases.

The EU has targeted carbon-intensive regions to try to prevent known outcomes from mining phase-out including mass unemployment, local economic crises, and the rise of far-right populist parties (Huber et al., 2021). Phase-out has far-reaching consequences for those involved in coal economies including energy companies, mine and plant employees, local service industries, institutions of higher education, local municipalities generating tax revenues, and more. Affected networks can function as a potent force against decarbonization, especially when backed by the state (Autho2, 2019; Rosenbloom et al., 2018;

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Rosenbloom and Rindscheid, 2020; Sillak and Kanger, 2020).

The high risk of negative outcomes, and resistance to decarbonization has led to increasing calls for just transition: maximizing the social and economic opportunities of climate action, while minimizing and carefully managing any challenges (European Commission, 2020a). Existing literature highlights various means for doing so, including providing worker compensation and retraining opportunities, diversifying regional economies, improving carbon-intensive regions' environmental standards, supporting experimentation with transformative innovations, and providing dedicated financial aid mechanisms (Oei et al., 2019; Ziouzios et al., 2021; Author2 and Author1, *under review*). For example, in 2020 the European Commission (EC) launched the Just Transition Mechanism, mobilizing €55 billion for 2021–2027 in the most affected regions, to alleviate the socio-economic impact of the transition (Linton et al., 2021; Nacke et al., 2023).

Our study investigates the conditions, and the timeframes, in which this mechanism will have a visible effect on coal-intensive regions. While previous studies have analysed what *should happen* for Just Transition to be successful, we focus on what *is already happening*, or *is likely to happen* soon.

We have analysed possible responses to decarbonization to better understand how different actors cope with decarbonization policies and what this means for how transitions progress (Author2 and Author1, *under review*). This paper uses the resultant database of coping strategies (Author2 et al., 2023) to examine how, when, and why regional actors in four carbon-intensive regions move from resisting decarbonization to adopting strategies that help advance this process. The concept of a coping strategy, which sociology borrowed from psychology, refers to actions, or thought processes used in meeting stressful or unpleasant situations or in modifying one's reaction to such a situation (Folkman and Moskowitz, 2000). Here we use this concept to refer to a spectrum of strategies that range from resistance to adaptation to transformation that are implemented by individuals or groups of actors.

Europe's coal regions are very diverse. Some are solely dependent on mining while others have more diverse economies, allowing workers from affected industries to move to other sectors through retraining without migrating. This empirical study tests current theorizations on phases of decarbonization in four cases: Western Macedonia in Greece, and Ida-Virumaa in Estonia are heavily dependent on carbon-based industries, while Silesia in Poland and North Rhine-Westphalia in Germany have more diverse economies. These regions are all carbon-intensive, and they have broadly different economic and demographic characteristics: studying them in parallel can provide insight on different ways of transitioning for other European regions. We aim to investigate the transition dynamics in the four regions to establish whether an underlying common but differentiated pathway can be identified across them that can provide policymakers with useful indications about how to favour a just transition.

In the next section, we establish theoretical grounding, building on sustainability studies and rapidly advancing research on decarbonization policy. This is followed by methodology and short descriptions of case studies. In the fifth section, we analyse regional case results. In thew sixth section, we summarize the identified transition phases. Discussion and Conclusions follow.

2. Theoretical background

2.1. Phases of transitions

This work employs concepts from two strands of literature: phases of energy transition, and just transitions. "Phases" of energy transition are the stages that a country or region typically (but not necessarily) goes through as it shifts from a carbon-based to a low-carbon economy. Each phase of transition is characterised by different challenges and opportunities, such as the availability of renewable energy sources, political will, and public support for decarbonization (Nacke et al., 2023).

Perspectives on transition phases are often grounded in studies on technological diffusion and sustainability transitions, and science and technology studies. While phase transition theory can be applied on different scales–national, regional, local–, the literature we refer to in this study especially focuses on regional energy systems: that is, it takes regional political and socioeconomic transitional dynamics as its main object of study. However, the different scales do heavily interact, as we explain in the next sections especially regarding the establishment of EU-wide or country-wide funding for just transition. On an even broader scale, geopolitical factors and resource diplomacy also affect continental transition policies–as shown by the consequences of the Russian full-scale invasion of Ukraine in 2022 on the EU's energy security and supply systems, or by China's blockade of rare earths' processing technologies in December 2023, which affected the manufacturing of "smart" and "green" technologies.[1]

Nacke et al. (2023) have relied on work by Ostrom et al. (2007), and on socio-technical systems theory (Geels et al., 2007), to create a diagnostic framework to help understand appropriate policy sequencing and feasible transition pathways in resource-dependent regions. Describing the main policy areas in decarbonization as a) the phase-out of fossil fuels; b) responses from firms and industries; and c) regional strategies for socioeconomic recovery, they identify three phases of transition, depending on whether one considers regional, industrial, or technological systems. They argue that regional systems move from a phase of stability (Phase 1) to one of release and shutdown (Phase 2), to one of reorganization (Phase 3); industrial systems evolve from maturity (Phase 1) to shake-out (Phase 2), to upgrade or exit (Phase 3); and, technological systems shift from lock-in (Phase 1) to destabilization and decay (Phase 2), to phase-out (Phase 3). They maintain that the main risks in each phase are, respectively: lock-in or persistence of the status quo; backlash from affected companies and workers; and regional despondency.

The interaction between these different levels in relation to just transition dynamics also emerges in recent work by Author2 and Author1 (*under review*), which investigates actions undertaken by different actors to cope with decarbonization policies. On this continuum of coping strategies, actions of resistance are at one end, actions seeking to adapt to and substitute new energy resources are in the middle, and actions seeking broader social and economic reorganization leading to systems transformation are at the far end. Strategies of resistance seek to preserve current conditions and can manifest as efforts to preserve fossil fuel economies, or to prevent perceived or anticipated injustices related to the development of renewable energy-based economies (Sovacool et al., 2022). Adaptation strategies seek to shift from fossil fuel- to renewable energy-based economies while preserving existing power relationships and the broader industrial setting (Barnes et al., 2017; O'Brien, 2012). Transformative strategies seek a reorganization of systems of production and consumption (Scoones et al., 2020; Barnes et al., 2017). The lines between strategy types are fuzzy as the threshold for a change to be considered transformative is often qualitative, and adaptive actions can become transformative when accumulated over time (Barnes et al., 2017; Scoones et al., 2020). In addition, implementing adaptive change can be another way to resist broader changes (e.g., by the industry), and thus often overlap resistance strategies. Finally, the distance between resistance and transformation is often shorter than may be obvious as many resistance actions, particularly on the part of civil society or labour actors, represent a push for more transformative change (Author2 and Author1, *under review*). These strategies do not align perfectly with Nacke et al.'s (2023) phases of transition as actor responses are dynamic and, for example, resistance

[1] Siyi Liu and Dominique Patton, "China bans export of rare earths processing tech over national security", Reuters, 22 December 2023 (https://www.reuters.com/markets/commodities/china-bans-export-rare-earths-processing-technologies-2023–12-21/).

strategies can occur even at later transition phases.

In this respect, we found it useful to refer to theorization by Kanger et al. (2019), who have highlighted the need for alignment between social, policy, and business spheres of society to foster the adoption of technological innovations. Such alignment, we consider, is also crucial for energy transitions to take place. As regions move through transition phases, different dynamics manifest at different jurisdictional and geographical scales. We will therefore emphasise alignments and misalignments between local, regional, national, and transnational scales, and between the policy, society, and industrial sectors.

2.2. Just transitions and transition phases

The term "just transition" originated in the North American labour movement in the 1970s (Wang and Lo, 2021). "Just transition" represents a fair and equitable transition from a carbon-based to a low-carbon economy (Kleinman et al., 2020). In recent years, the concept has broadened to include a wider range of social groups, including communities that are dependent on high-carbon industries and low-income households that are disproportionately affected by the impacts of climate change. In general, the just transition literature emphasises the importance of engaging with affected communities and ensuring their voices are heard in the decision-making process (Wang and Lo, 2021). This requires building partnerships between different stakeholders, including workers, trade unions, civil society organisations, and government agencies (Kleinman et al., 2020). The literature also emphasises the need to provide support and training for workers who are transitioning out of high-carbon industries, ensuring that they have the skills and opportunities to participate in the new economy (Wright et al., 2020).

Despite its relatively long history, the just transition concept has only recently been widely adopted by governments; and research has mostly focused on policy development and implementation rather than on identifying temporal dynamics of transition (e.g., Swilling et al. (2016), on South Africa; Goddard and Farrelly (2018), and Snell (2018), on Australia; Harrahill and Douglas (2019), and Gürtler and Herberg (2023), on German regions; He et al. (2020), on China; Oyewo et al. (2021), on Ethiopia). The relative novelty of political strategies explicitly directed at implementing a just transition explains this research gap. That is also why we believe that an empirical study testing current conceptualizations of phases of decarbonization may prove useful and improve the chances of a successful just transition.

In analysing transition dynamics, we thus apply a framework considering phases of transition and movement between phases, alignments between different societal sectors, the coping strategies common in different phases, and the implications of actions across different scales for transition processes. For example, a national policy hinged on the dismissal of miners, if not properly designed, could have the spill-over effect of inducing miners to emigrate to other areas of the country or the EU, and cause harmful phenomena to the local economic and social fabric. A policy to incentivise the de-taxation of renewable energy companies in a region might entice foreign companies to establish themselves in the area, but without a concomitant creation of dedicated expertise in that sector, it might not have noticeable positive spill-over effects locally or regionally. We interpret actions and processes considering what they mean for just transition-related outcomes.

Our aim is to test the existing conceptualisations of phases of transition against our empirical results. We do assume that certain phases are identifiable in each region, but we show that they may not always correspond to those highlighted in the literature. Depending on the sectoral focus one chooses to adopt (economic, political, technological, etc.), the distinct phases may not only not coincide across regions, but the articulation of different sectors within the same region can also proceed at variable speed, with one sector being faster in taking up and implementing some degree of transitional measures than others, that being contingent on each region's history and socio-political context, and interaction across different scales of government (local, regional, national, supranational). Our analysis further shows that specific policy and, especially, financial measures taken at the supranational level (EU's Just Transition Fund, in our case) are among the few enablers of concrete change at lower scales. Our theoretical contribution lies in complexifying the transition phases theory through its hybridisation with multi-level alignment theory and showing the differentiated development of phases depending on sectoral alignment and societal embedding.

Table 1
Selected word strings.

Region	National daily	Regional daily
Ida-Virumaa	"Ida-Virumaa" and "põlevkivi"	"Ida-Virumaa" and "põlevkivi"
NRW	"Energiewende"	"Energiewende"
Silesia	"transformacj* energetyczn*" AND (śląsk* OR Katowic*) "sprawiedliw* transformacj*" AND (śląsk* OR Katowic*)	"transformacj* energetyczn*" OR "sprawiedliw* transformacj*"
Western Macedonia	"ενεργειακ* μετάβασ*" AND ("δυτικ* μακεδονί*" OR Κοζάν*) "δίκαι* μετάβασ*" AND ("δυτικ* μακεδονί*" OR Κοζάν*)	"ενεργειακ* μετάβασ*" OR "δίκαι* μετάβασ*"

3. Methods

We adopted a multiple case study design focusing on decarbonization pressures and related coping strategies in the four target regions. While the four regions differ markedly with respect to several macroscopic parameters – e.g., demography, economic history, rate of development of renewables – we chose this design for three reasons: i) according to Flyvbjerg (2006: 230), by selecting a sample which has maximum variation among its cases, significance of various circumstances for processes and outcomes can be obtained; ii) these regions are all carbon-intensive, and they have broadly different economic, historical and demographic characteristics, and so comparing them can provide data on different ways of transitioning for other European regions; and, iii) representativeness grounds: the four regions represent countries with markedly different historical trajectories, two of them having experienced socialist regimes; two, capitalist regimes; geographically they also represent northern, southern, western, and eastern Europe.

A mixed methods approach was used to collect information on the strategies being used to cope with decarbonization policies and to triangulate across data sources. Sources included a media analysis of major national and regional newspapers, interviews with key informants, focus groups, and a grey and academic document review.

Media analysis spanned seven years (2015–2021), but contextual information on each region is provided for events prior to 2015: for that period, we mobilised published and grey literature, as well as expert interviews, as sources that helped our interpretation of trends that appeared, and decisions that were taken in the 2015–21 period. Contextual information was also used to provide a picture of the situation in energy matters in each region at the starting year of our press analysis. Data collection for the 2015–2021 period started from Paris Agreement adoption as this was a milestone of global energy transition. Despite the differing initial conditions of each region, for a press analysis such as the one we conduct, we consider that selecting the same period for analysis is an essential condition for data consistency. Data was collected using searches for word strings in 1) newspaper articles from one national and one regional newspaper per region; 2) articles published by other online newspapers to fill in gaps from the target newspapers. The target newspapers were chosen based on circulation and archive availability. These were: 1) *Ta Nea* (Greece, national), *Kozani* (Western Macedonia); 2) *Gazeta Wyborcza*, national and Katowice

Table 2
Total energy supply (TES) by source 2015 (TJ).

2015	Coal	Natural gas	Nuclear	Hydro	Biofuels and waste	Oil	Wind, solar, etc.	Total
Estonia	137,355	16,347	0	97	38,408	12,050	2573	206,830
Greece	234,727	112,077	0	21,952	58,538	469,343	41,941	938,578
Germany	3,324,712	2,727,881	1,001,301	68,317	1,277,310	4,238,841	466,311	13,104,673
Poland	2,023,504	576,764	0	6595	348,796	976,349	42,088	3,974,096

Table 3
Total energy supply (TES) by source in % (2015).

2015	Coal	Natural gas	Nuclear	Hydro	Biofuels and waste	Oil	Wind, solar, etc.
Estonia	66.4	7.9	0.0	0.0	18.6	5.8	1.2
Greece	25.0	11.9	0.0	2.3	6.2	50.0	4.5
Germany	25.4	20.8	7.6	0.5	9.7	32.3	3.6
Poland	50.9	14.5	0.0	0.2	8.8	24.6	1.1

editions (Silesia); 3) *Postimees*, national and Ida-Virumaa editions (Ida-Virumaa); 4) *Süddeutsche Zeitung*, national and NR-W editions (NR-W). The search was conducted using the LexisNexis® database for national newspapers. For regional newspapers that were not indexed, newspaper websites were used. For each source, search strings reflected contextual specificities while preserving our focus on energy transition (Table 1).

Articles were searched in the main official language of each of the four countries and then translated and filtered for relevance. To these articles were added those obtained from the free web search creating a final pool of 843 articles. The database was explored to identify coping actions. We coded the articles using NVivo® qualitative analysis software to identify location, timing, targeted problem, type of actor, nature of action, and intended outcomes. Timelines of coping strategies were compiled for each region, including triggering events on multiple levels and changes in actor strategies over time.

To reduce the risk of missing coping strategies that were not considered newsworthy, additional validation was sought via 16 semi-structured interviews with experts from NGOs, industry, consultancy firms, academia, and policymakers, and eight focus groups–two per region–with local stakeholders. Participants in the interviews were chosen based on snowball sampling, starting from the contacts the authors had from the Horizon 2020 "Carbon-Intensive Regions in Transition" (CINTRAN) Project, in which both have been involved. For each region, we aimed at a diversified sample in terms of interviewees' sectors of affiliation. The interviews were conducted remotely, via a virtual meeting platform, with participants based in the four regions under study, and lasted 1 to 1.5 h. The questions focused on the most significant events that occurred at the policy, social, economic, and industrial levels in the energy realm over the past decades in each region, with a specific emphasis on identifying regional coping strategies since 2015. Experts' opinion was also asked on the current transition dynamics, and on their benefits and pitfalls.

Focus group participants were recruited at the local level in each of the four regions using a marketing research firm. Participants were chosen to reflect a diversity of age ranges, gender, and employment fields, including the social or charity sector, local government, and local business. Two focus groups of five participants each were held in each of the four regions. One group in Estonia had six participants, resulting in a total of 41 participants. Questions focused on validating and extending previously identified coping strategies and providing insights on key actors and their actions in each region. Once transcribed, the interviews and focus groups were also analysed and coded using NVivo®.

We then proceeded to identify periods within our regional timelines (periodization). The periodization was informed by our interpretation of the prevalence of specific events (resistive, adaptive, transformative) in each region, drawn from our press analysis and from existing literature. For example, a decrease in resisting events (such as strikes to defend fossil fuel industry jobs, or policymakers' speeches in favour of keeping mines open) and a simultaneous increase in adaptive events (such as the enactment of measures to foster retraining of miners, or the introduction of regulations to improve energy efficiency in buildings) was interpreted as an indication of a transition from Phase 1 to Phase 2. We preferred to base our assessment of phase transitions both on quantitative and qualitative considerations: consequently, we did not only count the number of events but also evaluated the political significance and magnitude of each (for example, whether a policy was adopted at a municipal, regional, or national scale). Consequently, the reproducibility of our results depends on a shared view of such considerations. That notwithstanding, we believe that our analysis takes due account of the most significant political, industrial, and socioeconomic events that occurred in the period under study and provides an accurate picture of transition phases.

4. Case descriptions

4.1. Cross-case characteristics

Our case studies are characterised by markedly different socio-demographic, political and economic histories with impacts on the energy supply of each region and country. In Tables 2 and 3 we report total energy supply by source for each country at the starting point of our analysis, in 2015.[2] While these figures do not show the evolution in the use of the different sources mentioned, they provide an indication of where these countries were at the starting moment of our analysis. From them it emerges, for example, that Estonia was heavily dependent on fossil fuels (shale oil, in particular) and had limited renewable energy production. Poland was in a similar situation, with its fossil fuel dependency even stronger than Estonia. Greece and Germany, on the contrary, already had a significant renewable sector, with Greece producing almost 7 % and Germany slightly over 4 % of their energy from renewable sources. Only Germany produced electricity from nuclear sources.

On a regional level, recent research shows that Western Macedonia and Silesia are characterised by the highest socioeconomic risk among the 15 most coal-intensive EU regions. They show high vulnerability (an index including unemployment, GDP, income, investment, regional competitiveness, and population over 50 years old), high hazard (due to the significant planned change of domestic production in fossil fuel-related sectors by 2050) and high exposure (share of employment in fossil fuel-related sectors to total). Ida-Virumaa scored fifth in socio-economic risk. The regions mostly exposed to socioeconomic risks of the low carbon transition are those with a high share of direct fossil-fuel jobs. This share was around 6.5 % in Western Macedonia and Silesia in (2015 data), much above the 2.5 % average of all top-15 high risk

[2] Data for Tables 1 and 2 was extracted from https://www.iea.org/countries/ .

regions (Vrontisi et al., 2023: 22). Regions in Germany, which ranks second in Just Transition Fund (JTF) allocations amongst the EU 27, were not identified as regions at risk. This is due to their lower sensitivity and higher adaptive capacity (ibid., 69).

4.2. Ida-Virumaa, Estonia

Ida-Virumaa County is in north-eastern Estonia, bordering Russia. It had a declining population of 131,913 in 2021. Based on the Estonian 2021 census, most of the population is ethnically Russian (74.1 %) (Statistics Estonia, 2021). The unemployment rate in 2021 was 11.5 % (against a national average of 6.2 %) (ibid.). The central role of oil shale in Ida-Virumaa's regional economy reflects a legacy of Soviet occupation when oil shale for energy and chemical production was introduced by the regime after World War II (Holmberg, 2008). While the shale oil industry has long been crucial for the regional economy, the number of workers employed in the regional oil shale sector has been decreasing since the late 1990 s (despite an increase between 2006 and 2009): slightly less than 7,000 people were employed in 2015 and 5,900 in 2021 (Murula and Kuusmik, 2022). Oil shale production is responsible for a range of environmental and health related impacts in Ida-Virumaa (Keskkonnaministeerium, 2015; Idavain et al., 2020). However, the dominant narrative amongst policymakers and industry actors (Holmgren et al., 2019) treats oil shale as a guarantor of energy independence and political stability. Until recently Estonia had one of the lowest energy import dependencies of all EU countries (IEA, 2019), but also one of the highest ecological footprints (Global Footprint Network, 2017). Estonian policymakers have "hedged their bets" by providing simultaneous support for international environmental goals and the domestic oil shale industry (Sillak and Kanger, 2020). Renewable energy infrastructure in Ida-Virumaa (solar, wind and hydro) in 2015 was limited to one wind plant (Narva, 39 MW, 18 turbines), commissioned in 2012.[3]

4.3. North Rhine-Westphalia, Germany

The state of North Rhine-Westphalia (NR-W) is in west-central Germany, bordering Belgium and the Netherlands. With a population of just under 18 million, it is the most populous region in the country. The region has a strong tradition of heavy industry and includes the Ruhr mining sub-region. The unemployment rate is 7 % (compared to a German average of 5.4 %) (Bundesagentur für Arbeit – Statistik, 2022). The NR-W region is not new to transitions: starting in the late 1950 s, with the liberalization of coal prices, regional coal production started to decline (Grabher, 1991). Redundant miners were either re-employed in the region's metallurgical industries or given the opportunity for early retirement, receiving redundancy payments (Nonn, 2001; Oei et al., 2019). Retraining options were also provided from the late 1960s. Between the 1980s and the 1990s, following the oil crises of the 1970s, governments promoted a tertiarisation of the regional economy. Hard coal was gradually abandoned, with the last mine closing in 2018 (Oei et al., 2020).

According to the Federal Institute for Geosciences and Natural Resources (BGR), in 2015, there were 9,640 people employed in hard coal mining and about 15,500 in lignite mining business in Germany (BGR, 2016): about 7,500 and 7,000 of them, respectively, in NR-W (Ministry of Economics of NR-W, 2016: 9, 10). An important institutional step for energy transition was made in 2014, when municipalities, business associations, and the mining and energy trade union became shareholders in the *Innovationsregion Rheinisches Revier*, later renamed *Zukunftsagentur Rheinisches Revier* (Future Agency of the Rhenish Region, ZRR). The agency was charged with developing a shared vision and a regional development strategy; and with conducting studies on the prospects of specific industry branches (European Commission, 2020b). With respect to renewable energy, NR-W has been one of the earliest takers in Germany: while in 2001 the share of renewables in the power mix was less than 1 %, it reached 8 % in 2009, and 12.4 % in 2015 (Ministry of Agriculture of NR-W, 2021).

Table 4
Synoptic table of basic data on case study regions.

	Ida-Virumaa	NR-W	Silesia	W. Macedonia
Population	131.913	17,600,000	4,570,000	280.000
Unemployment (%)	11.5	7.0	3.9	19.8
Number of fossil-fuel industries' workers (mines, thermal plants, coal-related businesses)	5.900	15.000	98,000 (of which 73,000 in mines)	15,600 (of which 4,600 in mines)

4.4. Silesia, Poland

Silesia, in Poland's south, has a population of 4.4 million and is the country's main mining region. The unemployment rate is the country's lowest (3.9 %, compared to a national average of 5.2 %) (Invest in Silesia, 2022; Statistics Poland, 2022). In 2019, almost 80 % of those employed in Polish coal mines came from Silesia (73,000 people) (European Commission, 2020c: 2, 4; Nowakowska et al, 2021). However, the sector's production has been declining over the last three decades due to lower productivity and profitability (Szpor, 2017; Baran et al., 2018). The number of people employed in the regional hard coal mining sector (also including thermal power plants and other coal-related activities) was 388,000 in 1990, but collapsed to 98,000 in 2015 (European Commission, 2020c). The decline in production and mining jobs was also a consequence of dedicated, national governmental policies: between 1993 and 1998, four programs were launched to restructure the sector and make it profitable, with mixed fortunes (Zientara, 2007; Szpor 2017; Brauers and Oei, 2020). As in the Ida-Virumaa case, in Silesia too no wind, solar, or hydro infrastructure was present in 2015.

4.5. Western Macedonia, Greece

The region of Western Macedonia, in north-western Greece, has a population of 255,000. It is the largest lignite extraction region in Greece, and is home to the Western Macedonia Lignite Centre, a network of surface coal mines, owned by the Public Power Corporation (PPC). Over the last decade, production at the complex has declined significantly, from 43.2 million tons in 2010 to 10.3 million tons in 2020 (Pavloudakis et al, 2022). Western Macedonia has one of the highest unemployment rates in Europe: 19.8 %, against a national average of 14.8 % (The World Bank, 2022; European Commission, 2022). An estimated 16,000 jobs could be affected by the closure of the mines: 4,600 direct jobs, with a further 11,000 indirect ones (Christiaensen and Ferré, 2020: 6). Since the 1950 s, the regional economy has been characterised by coal extraction and the thermal energy generation industry: the trend in employment in the mining and quarrying in the region has been oscillating: 4,755 people were employed in this sector in 2011 and 5,084 in 2015. 2,273 were employed in electric power generation, transmission, and distribution in 2011 (2,248 in 2015) (Christiaensen and Ferré, 2020: 16). At the beginning of 2015, renewables in Western Macedonia were anything but negligible: the Polyfytos hydro-power plant had an installed capacity of 375 MW, while the Ilarion hydro-

[3] Liina Vladre, "Liive: Narva tuulepark on ilmselt lähiaja viimane suur tuulepark", *Postimees Majandus*, 4 September 2013 (https://majandus.postimees.ee/1386500/liive-narva-tuulepark-on-ilmselt-lahiaja-viimane-suur-tuulepark); Hardi Murula, Association of Local Authorities Ida-Viru County, personal communication.

plant provided an additional 154 MW capacity (there were also other, much smaller hydro-power plants) (Malamatenios et al., 2022); 52.8 MW of wind power were installed (HWEA, 2015). No data was available for solar energy for 2015, but in January 2019 there were 112.9 MW of PV systems, and 8.4 MW biogas.[4] Basic data on the four case-study regions is reported in Table 4.

5. Results

In this section, actions for each region are grouped into "periods" characterised by distinct dynamics. These are then analysed in the Discussion.

5.1. Ida-Virumaa

5.1.1. Period 1: Adapting to industry destabilization (2015–2018)

In 2014, the Ministry of the Environment proposed to raise environmental charges to reduce harmful impacts from resource use, pollution, and waste removal. This led to a public campaign by the Federation of Estonian Chemical Industries, stressing oil shale as a pillar of energy security, and a counter-campaign by environmental movements to connect energy security to renewables (Sillak and Kanger, 2020). From 2014, a sharp drop in global crude oil prices compromised oil shale profits. Viru Keemia Grupp (VKG) – a major energy enterprise in Ida-Virumaa – temporarily closed two oil factories and made 500 people redundant. 200 miners were also laid off in 2015 by another key player in the region: state-owned enterprise Eesti Energia (Kreek, 2015).

The government quickly enacted a series of measures to stabilise the oil shale industry and regional employment. These included consultations for redundant workers and subsidies for new job creation by the Unemployment Office, through the European Global Adjustment Fund (€1.1 million approved by the EC in November 2016) (Vahtla, 2016), reducing resource and environment taxes (temporary measures in 2017–2018) (Hansalu, 2016), and proposing to subsidise increased use of biomass in power plants to keep them operating. In parallel, the government signed a decree heavily restricting the creation of new wind parks, arguing that they would disrupt the military's air and radio surveillance capabilities. This undermined the planning of nine wind parks in Northern Estonia (Reimer, 2016a). The biomass-incentivising measures were successful and in July 2016 VKG announced reopening of the two closed factories and rehired 350 miners and chemists (Reimer, 2016b).

Many of these support measures were challenged as unfair. Wind energy producers sued local municipalities for issuing and then retracting permits for wind energy parks in Päite-Vaivina (the decision was upheld by the Supreme Court of Estonia in 2021). Court battles with the state centred around the excessive height of turbines in Aidu (Ruuda, 2017; Aaspöllu, 2021). In 2017, Estonian bioenergy producers filed two complaints with the EC arguing that a planned subsidy scheme allowing Eesti Energia to burn 500,000 cubic meters of wood for electricity would distort the biomass market. Protests subsided when the Commission found no legal obstacles to the implementation of this measure (Reimer, 2018). A need for more transformative change was stressed by an NGO (Eesti Roheline Liikumine), which started a petition for "Põxit" ("oil shale" + "exit") in 2017. Signed by 1,079 people the petition was discussed by the Parliament which eventually decided that there was no need for a separate strategy (Riigikogu Keskkonnakomisjon, 2018).

5.1.2. Period 2: Emergence of the Just Transition agenda (2019–2021)

This phase marked a turn in Estonia's energy supply as increasing EU's carbon prices started to undermine oil shale profitability. In 2019, the share of oil shale in energy production dropped from 76 % to 57 % (Statistikaamet, 2020), and close to 50 % in 2020 (Elering, 2021). Eesti Energia reacted in 2019 with 450 redundancies and sending 1,300 more on mandatory vacation (Pärgma, 2019). Once again, the government responded through a series of adaptive measures: reclassifying oil shale ash as a non-hazardous waste to enable its use as a product (late 2019) and approving a €125 million investment in a new shale oil plant in Auvere (early 2020). 2019 also marked the emergence of just transition rhetoric in public discourse, reflected in intensified discussions about the future of Ida-Virumaa by environmental activists, policymakers, entrepreneurs, and scientists. Some of the proposed solutions included drafting a strategy for oil shale phase-out with clear deadlines; developing regional capabilities in renewable energy production, carbon capture and storage, and hydrogen technologies; renewing the curricula of regional colleges; and, supporting new economic activities in the region (e.g., Roosileht, 2020; Murula, 2020). The government decided to buy a new radar system for Ida-Virumaa by 2024, making it easier to build new wind energy parks in the region (2019), and used EU funds to allocate €273 million to Ida-Virumaa for job creation and entrepreneurial support, and another €66.7 million for improving the living environment (2021). A new government in 2021 also committed to developing the plan for just transition in Ida-Virumaa in collaboration with local stakeholders. However, specific actions and regional future visions remain heavily contested. For example, the CEO of VKG has criticised planned compensation measures for the oil shale sector as grossly insufficient (Asmann, 2020).

5.2. North Rhine-Westphalia (NR-W)

5.2.1. Period 1 (2015–17): early political attempts to phase out coal, and industrial reaction

The period starting in 2015 was marked by national government attempts to enact adaptive strategies, and by consequent resistance actions from the regional level and the industrial sector. In February, the Federal Economics Minister made a proposal to institute a new "climate levy" policy measure to reduce CO_2 emissions from carbon-intensive coal plants (Balser, 2015a). The proposal was ultimately scrapped due to opposition from energy utilities, trade unions, and three regional governors. Energy utilities argued that coal phase-out should not happen too quickly. Unions and regional authorities made a counterproposal for a slower coal phase-out and the replacement of coal-fired plants with gas (Balser, 2015b; Balser and Bauchmüller, 2015).

The federal government finally agreed to implement a 2.7 GW capacity reserve for lignite plants which would pay plant operators to put their power stations on standby and subsequently shut them down after 2020 (Schulz and Schwartzkopff, 2015; Radowitz, 2015). In late winter, the German energy giant, E.On, announced it would split and concentrate on green energy and grids, with the newly-established company, Uniper, managing conventional power generation (Balser, 2015a).[5] In August, Germany's other energy giant, RWE, also announced a restructuring plan, creating renewable energy-focused Innogy (Balser, 2015c). In 2017, RWE opened a wind farm in Bedburg on a recultivated former mine site with the local municipality as a shareholder. (Bauchmüller, 2017).

5.2.2. Period 2 (2018–21): The Coal Commission and early transformative actions

In June 2018, the federal government established a Coal Commission composed of political figures, members of industry, academia, envi-

[4] Charalampos Malamatenios, Center for Renewable Energy Sources (CRES), personal communication based on data from the Greek Statistics Institute (ELSTAT) and Regulatory Authority for Energy (RAE).

[5] The split became effective in January 2016.

ronmental organizations, unions, and "lay" representatives of coal regions. The commission was charged with suggesting measures for the social and structural development of Germany's coal regions. After the publication of the Coal Commission's recommendations in January 2019,[6] RWE published a statement on the negative consequences of these recommendations for industry (Bauchmüller, 2019a), while the IG BCE union warned that jobs and economic benefits of mining would not be easily replaced (Bauchmüller, 2019b).

There were also tensions on the renewable infrastructure front. In July 2019, lawsuits were started at the national level by several nature conservation NGOs against wind farms (Bauchmüller, 2019c). By then, the installed capacity of both wind turbines and PV in NR-W had almost reached 6 GW (Ministry of Economics of NR-W, 2021), and the gross power consumption accounted for by renewable energies was just over 12 % (Ministry of Economics of NR-W, 2021). In September, the Federal Minister of Economics organised a summit on wind power in Berlin, to which he invited representatives from regions, companies, and from anti-wind power citizen's groups (Bauchmüller, 2019d). Two years later, the NR-W government decided to impose a minimum distance of 1,000 m between residential areas and wind turbines (Bauchmüller, 2021).

The fossil and heavy industry did not only resist coal phase-out. It also increased investments in renewable energy (e.g., geothermal energy and solar water heat collection in disused mines by RWE) and in industrial processes (e.g., steel production using hydrogen produced from renewables by Thyssenkrupp) (Müller, 2019a; Müller, 2019b). From 2019 until the end of the analysis period, there was an increase in the number of projects on energy efficiency, renewables installations, and the creation of new economic activities. For example, in August, the German Trade Union Confederation put forth a proposal to turn Thyssenkrupp's Duisburg plant into a green steel plant that runs on hydrogen (Wernicke, 2021).

5.3. Silesia

5.3.1. Period 1 (2015): mining strikes and government change

From early 2015 to the change of government in November of the same year, activity was characterised by resistance from miners and trade unions. From the end of 2014, protests organised by Poland's unions halted work in Silesia's mines in response to the proposed closure of four loss-making mines operated by the state-owned company *Kompania Węglowa* (KW, since 2015 *Polska Grupa Górnictwa*, PGG). Miners staged underground and street protests (Solidarność Górnicza, 2015), hunger and underground strikes, and railroad blockades. Some of these protests would continue until the end of the year (Trzeciak and Maleszka, 2015). Mid-January, the government decided that the four mines would be transferred to a state-owned company, the Mine Restructuring Company (*Spółka Restrukturyzacji Kopalń*), for recapitalization with public funds. Protests resumed a few days later at another mining complex, *Jastrzębska Spółka Węglowa*, following the company board's termination of the 2011 collective bargaining agreements, removal of employee benefits, and a shift to a six-day work week. The strike ended with the resignation of the chairman, but not the withdrawal of changed conditions (Salzmann, 2015). Following the election of right-wing national conservatives, traditionally supportive of the coal industry, in November 2015, miners appeared reassured about the future of their jobs, and resistance strategies temporarily ended.

[6] The results were submitted in January 2019. It recommended phase-out of the entire fleet of 84 coal-fired plants by 2038, and to preserve the Hambach Forest from mine expansion, which had been the stage of strong protests by political activists and ecologists in August 2018 (Brock and Dunlap, 2018; Liersch and Stegmaier, 2022; Mohr and Smits, 2022).

5.3.2. Period 2 (2016–19): early industrial initiatives and the Silesia Declaration

2016 to 2019 was characterised by the emergence of new renewable energy actors. In October 2017, a project to build a solar cluster in Jelenia Góra was launched and, in November 2018, a wind farm project was started in Zukowice. In March 2019, the company ElectroMobility Poland announced plans to build Polish-made electric vehicles by 2023 (Dziennik.pl, 2019). At the same time, studies on possibilities for adaptation and transformation of the Silesian energy economy were published by consulting agencies, think tanks, and NGOs (Jedlecki, 2017; Bukowski et al, 2018; Baran et al, 2018). The international community became more influential as COP24 was hosted in the Silesian city of Katowice.

In December 2018, during COP 24, the Polish COP President coordinated the international Silesian Declaration of Solidarity and Just Transition. This represented a significant milestone for coal-intensive regions, and Silesian miners especially, sending a crucial message that workers would not be sacrificed to reduce emissions and halt climate change, and that the new, low-carbon economy would be equitable and inclusive (Levaï and Vallejo, 2018).

5.3.3. Period 3 (2020–21): government-unions agreement, and new mines blocked

From our press analysis, it appears that the prospect of grants from the EC under what would become the JTF made government structures more receptive to European policies and stimulated industrial actors' and policymakers' proactivity. In this period, both energy and non-energy companies were particularly active in designing initiatives and projects for the economic and industrial diversification of Silesia (Strzałkowski, 2020).

In September 2020, tensions in the mining sector resumed, following the failure of negotiations between unions and the government over mining sector restructuring (Barteczko, 2020). This was resolved in October, with the government committing to keep the mines active until 2049 and provide several benefits to miners (Czoik, 2021). The government's decision to delay coal phase-out to 2049 caused dismay amongst environmental NGOs, who criticised the agreement (Bednarek and Pietraszewski, 2021; Białas, 2021; Strzałkowski, 2021).

In this period, actions on both the regional and national level were influenced by the EC's establishment of the JTF. Possibly also as a result of civil society's pressure (European Commission, 2020c: 8), in February 2021, when the Council of Ministers adopted the "Energy policy of Poland until 2040", it emphasised that transition should be participatory, conducted locally, and initiated bottom-up (Ministry of Climate and Environment, 2021).

This period ended with conflict between national and local levels regarding coal mines. In Rybnik in 2019, the government authorised the opening of a new coal mine by a Polish private company, BAPRO (Król, 2019). Following citizens' protests, the local authorities decided to block the process, to which BAPRO responded with a legal complaint. The Provincial Administrative Court in Gliwice dismissed the case in September 2021. (Biernat, 2021). A similar episode occurred in Mysłowice, where regional authorities authorised a new coal mine in 2021. The mayor initially supported the operation but later opposed it after pressure from local citizens, with the help of environmentalist associations, after it became apparent that the EU could block money from the JTF for the whole subregion if the new mine was approved (Jedlecki, 2021).

5.4. Western Macedonia

5.4.1. Period 1 (2015–17): unions' resistance and local adaptive initiatives

After Greece's 2015 EU and IMF bailout agreement, the national government, led by a left-wing coalition, forced PPC to divest a 25 % stake to the state for € 296 million (Reuters Staff, 2017). This caused alarm among PPC workers and local authorities, worried by the prospect

of seeing PPC sold to private investors, and jobs cut (Efkozani.gr, 2015; Efkozani.gr, 2016). Resistance actions were undertaken by mining-related unions and workers, and some regional councillors (Efkozani.gr, 2017).

Adaptive strategies were mostly local, mainly upon the initiative of the then-mayor of Kozani, Eleftherios Ioannidis, who frequently intervened in the media advocating the establishment of a just transition fund, first at the national and then at the EU level. Local authorities in Western Macedonia were early movers, and they likely had a significant effect on early talks to establish the JTF (Theodosiou, 2022). In February 2017, for example, Ioannidis led a visit of Western Macedonia officials to Brussels to explore the possibilities of raising financial resources.

5.4.2. *Period 2 (2018–19): international collaborations and proposals for a just transition fund*

Actors at the regional and local levels intensified adaptive activities in 2018 and 2019. Cooperation between regional and national governments allowed allocation of €60 million to the region for clean development actions (Efkozani.gr, 2019a). Ioannidis, by spearheading the Forum of Mayors for the Just Transition of Europe's Coal Regions, bridged the local and the international action levels (Amna.gr, 2018). In September, cooperation among European coal municipalities resulted in a Joint Declaration on Just Transition (Efkozani.gr, 2019b).

Following the election of more right-leaning governments in 2019, the new regional governor, Giorgos Kasapidis, focused on energy efficiency projects, and in September organised a regional debate on the use of hydrogen as a fuel for district heating (Efkozani.gr, 2019c). In December, the national government institutionalised transition management by establishing a Committee for the Just Development Transition of Western Macedonia and Megalopolis (SDAM).

5.4.3. *Period 3 (2020–21): The JTF stimulates transformative actions*

The third period was characterised by resistance, adaptation, and transformation activities in parallel. In March 2020, the national government delivered a Just Transition Plan to Climate Neutrality. This was followed by a Territorial Plan for Western Macedonia. A Just Transition Institute was also established in Kozani. The definition of these plans and the promise of financial aid from the EU sparked adaptive and transformative proposals by policymakers and entrepreneurs alike (Efkozani.gr, 2021a; Efkozani.gr, 2021b).

In December 2020, the Regional Council approved a draft statute for energy communities between the Region, 13 municipalities and the University of Western Macedonia (Region of Western Macedonia, 2020). Many proposals came from the industrial sector and several projects for local energy efficiency were implemented (Ypodomes.com, 2020; Efkozani.gr, 2021c; Efkozani.gr, 2021d; Efkozani.gr, 2021e; Efkozani.gr, 2021f).

Supply was also a focus and in February 2020, the German solar energy company, Juwi, designed a project to build Greece's largest solar power plant (204 MW) (Efkozani.gr, 2020a). In August, PPC Renewables announced the construction of 1.9 GW of PV (Tzanne, 2020). Plans were made by public authorities to produce green hydrogen (Efkozani.gr, 2020b), build a battery storage system in Ptolemaida; while Greek and foreign private companies announced plans for biogas (Eunice Group, 2021) and solar power plants (Newsit.gr, 2021).[7] Renewables' developments also caused protests, especially with respect to wind farms (Efkozani.gr, 2020c; Efkozani.gr, 2021i) and solar plants and its impact on local landscapes (Todorović, 2021). Lack of involvement of local actors, as well as excessive centralism, were often underlined in these protests. In December, with the support of the government majority and the objections of the opposition, a bill on lignite phase-out and the just development transition was passed (Iefimerida.gr, 2021).

[7] The project – known as "White Dragon" – sent to the European Commission in November 2021 and ultimately scheduled to produce hydrogen from both gas and renewables, was scrapped from the list of projects of common interest of the EU in June 2022 (Efkozani.gr, 2021g; Efkozani.gr, 2021h).

6. Transition phases: case-study summaries

All four cases are unique in their histories, contexts, and transitions' pathways. However, analysis reveals insights that help describe movement between transition phases and provide better understanding of transitions' processes. These include the timing of resistance, adaptation and transformation strategies, alignment between geographical and political levels, importance of meaningful commitments to funding and support (Vrontisi et al., 2023), and typologies of transitional political, societal, and industrial developments. In this section, we first describe the transition phases we identified in our four regions. Then, we identify (mis)alignments between societal sectors within regional phases and enablers of transitions.

6.1. *Ida-Virumaa*

Using the taxonomy of Nacke et al. (2023), the first of the two periods in Ida-Virumaa is a transitional phase between Phases 1 and 2; there is socio-technical lock-in, but the industry is beginning to decline because of international dynamics (i.e., EU policies on emissions), and the regional system is experiencing downturn.

In 2014, the threat of industry destabilization that followed the drop in oil prices was addressed with sectoral adjustments. This caused the temporary misalignment of the regional shale oil sector and the national government. Once the crisis was over, the government re-aligned with the shale industry. The wind industry, on the other hand, remained misaligned until the second period, as did environmental NGOs that had proposed shale oil phase-out. Successive governments continued to rely on shale oil and hindered wind plants, but also supported biomass as a renewable fuel. In 2021, biomass accounted for 90 percent of the renewable energy generated in the country (IEA, 2021). One can therefore speak of a government strategy to date of resistance-adaptation.

From a just transition perspective, until the 2019 EU measures on carbon allowances, the government maintained a status quo position, prioritising continued operation of oil shale plants, but switching fuels to palliate the consequences of the oil price crisis. EU measures, however, accelerated destabilisation of the industry and is slowly leading to a transition to Phase 2 (destabilization and decay). As the EU's Just Transition Fund (JTF) materialised, the government's attitude became more flexible, but did not change dramatically, as evidenced by aid to the industry and the initiative to build another shale oil plant. However, national policy opened to wind power in the region. A visible trend started to emerge in policymakers' discourses, following the assignment of EU funds to the region, with interviewees moving from mistrust to moderate trust in transition initiatives. Such optimism was paralleled by a greater openness to social actors such as environmental NGOs or the Union of Municipalities.

6.2. *NR-W*

NR-W is in a middle to advanced Phase 2. Germany ceased hard coal production in 2018, following the cancellation of subsidies. NR-W is characterised by significant economic and industrial diversification, partly resulting from the long-term decline of lignite and the early development of a renewable energy industry. This decline in lignite use and increase in renewable energy capacity allowed time to build capacity for transition. The latest developments in transition policies, and particularly the creation of the ZRR, have allowed for a shared debate about the regional future. Industrial and technological system perspectives reveal an advanced Phase 2. However, regional social policies lag and are still being conceptualised. In terms of societal alignment, the first period from 2015 to 2017 is characterised by processes of action

and reaction as government actors proposed measures to further destabilise the lignite industry, and industry and labour unions acted to resist.

Executives of large fossil fuel corporations, aware of their core business's gradual decline, started diversifying and adapting. Large power companies created "sister" companies dedicated to renewables. The period between 2018 and 2021 was characterised by attempts for dialogue between industry and social groups, about both fossil and renewable industries. At the same time, there were clashes over the installation of wind farms between citizens and regional authorities. Investments in energy efficiency increased and industry made increasing efforts to transition to renewable energy. Although not yet in Phase 3 (technological phase-out, dismantling of the fossil industry and regional social reorganization), NR-W remains the most advanced among the regions we studied with respect to industrial and technological maturity.

In general, the history of NR-W has been marked by a strong regional alignment between the fossil industry and the state government, with gradually increasing "interferences" from the federal government and constant frictions with environmental NGOs. Because of the significant expansion in renewable energy installations – wind plants, especially – since the late 2000 s, there have also been misalignments between the renewable energy industry on one side, and the local population and authorities on the other.

6.3. Silesia

The situation in Silesia contrasts with that in NR-W. The Silesian coal industry has been declining for over a decade. Various measures taken half-heartedly by successive governments to prevent the closure of some mines were motivated more by politics than economics. The number of people employed in the industry has been steadily decreasing. However, because of strong lock-in, in the earliest period Silesia can be categorised as Phase 1, with strong union opposition to downsizing, continuous government support of coal, but also early signs of technological destabilization (characteristic of Phase 2), due to aging infrastructure and limited new development. In terms of multilevel alignment, the first period was marked by agreement between the national government and the regional coal industry, both of which aimed at making the coal system more profitable, either by closing unprofitable mines or by introducing new regulations to increase revenues and extract more work from miners. This was opposed by miners and trade unions.

A new, partial realignment of government and unions was reached when the government backed down on mine reorganization, and later, with the 2015 elections and election of a pro-mining majority. Regional unemployment was palliated by emigration, government subsidies to miners, and by the adaptation of laid-off miners to other industries. If the miners' strikes of 2015 demonstrated an entrenched industry, attempts to modernise were made in the second period with the first industrial initiatives in renewable energy and mobility. Our materials show that between 2016 and 2019, a new narrative, based on the expansion of renewables, rose to prominence thanks to the work of progressive think tanks, environmental NGOs, and the renewables industry. These actors opposed the existing alignment between the coal industry, the government, and the unions.

The significance of the transnational level in the second period is apparent in the 2018 Silesian Just Transition Declaration, which allowed a consolidation of European mining regions around the idea of just transition. Regional systems attempted to move to a more advanced phase of transition. However, these efforts were frustrated by the 2020 mining protests, which were resolved by the agreement between unions and the government for such a late phase-out date as to make it practically insignificant. This agreement marked a realignment between the national level and the mining unions but alienated environmental NGOs. Despite that, within the third period, increasing activity of civil society indicated civic and local municipality interest in a reorganisation of the regional industrial structure, foreshadowing the transition to a more advanced stage.

6.4. Western Macedonia

Western Macedonia is in a relatively advanced transition phase. However, economic diversification is still limited. The destabilization of the extractive industry, and the region's entry into Phase 2, was catalysed by the national economic crisis in 2008 which affected Greece more severely than other European countries. The need to divest from fossil fuels was matched by the need to address unemployment and economic development.

From 2015 to 2017, worker protests over PPC privatisation did not stop alternative energy production policies. However, resistance and adaptation actions, and regional and city activism (in Kozani, in particular) led governments of different levels to early formulations of a just transition narrative. As the technological and industrial system declined into Phase 2, regional reorganisation was beginning, characteristic of a more advanced transitional phase. This path was confirmed by the intensification of adaptation actions in 2018–19, with the allocation of the first funds for clean energy development, the internationalisation of Greek "diplomatic" initiatives on transition, and the first transformative actions—for example, the establishment of energy communities.

The 2015–17 period was characterised by misalignment between the national and regional levels, with the central government divesting from coal, and miners, unions, the fossil industry, and some regional councillors opposing. Some local authorities also developed their own strategies. They addressed the national and international levels to launch a just transition fund. The regional and local levels realigned with the national level from 2017, when coal divestment and funding opportunities became more concrete.

The creation of SDAM, in December 2019, institutionalised the concept of a just transition. The elections did not generate political misalignment, as the local, regional, and national all switched sides towards the same coalition. The industrial sector, especially non-fossil industries, now sure of incentives from the international level, remained aligned too.

In the last period, 2020–21, there were resistance, adaptive, and transformative actions. Resistance actions were directed at both the closure of thermal plants and the construction of renewables. Adaptive and transformative action, by far predominant, included programs for retraining workers, industrial diversification, energy communities, and declaration of a coal phase-out by 2023. The miners and related industries, reassured by new employment policies, also aligned with the other actors. Thus, Western Macedonia appears to be on its way to Phase 3 in all its three systems: regional, industrial and technological.

7. Discussion

In all cases, coping mechanisms do not follow a linear path. Instead, strategies oscillate back and forth between resistance, adaptation, and transformation, often with simultaneous actions with opposite or different goals, in different fields. However, there are trends evident in our cases, as theorised by Nacke et al. (2023) in their work outlining transition phases.

Resistance by local and regional levels, and industry, against fossil fuel phase out is common during the move from Phase 1 to Phase 2. In our cases this was obvious in worker protests and strikes in Ida-Virumaa, Silesia, and Western Macedonia. Germany has a longer history of coal phase-out, dating to the 1950 s, as well as a corporatist tradition in industry (Goodin et al., 1999) and a more diversified economy (Oei et al., 2020): that may have resulted in a perceived higher job security and a higher trust in unions-firms negotiations, and together with the presence in the country of a strong renewables lobby, made workers and unions less vocally resistant to a phase-out, even while high carbon industry heads pushed back. However, these same fossil industries were also

Table 5
Synoptic view of the periodization for the four case studies.

	2015	2016	2017	2018	2019	2020	2021
Ida-Virumaa	Adapting to industry destabilization				Emergence of the Just Transition agenda		
NR-W	Early political attempts to phase out coal, and industrial reaction				Coal Commission and early transformative actions		
Silesia	Mining strikes and government change	Early industrial initiatives & Silesia Declaration				Government-unions agreement and new mines blocked	
W. Macedonia	Unions' resistance and local adaptive initiatives			International collaborations and proposals for a JTF		JTF stimulates transformative actions	

simultaneously involved in adaptive actions (e.g., company restructuring, investing in renewables), and transformative actions (e.g., the German Coal Commission). This dual strategy is also common amongst regional and national governments in all countries who both supported coal and renewables, sometimes at the same time. Thus, in Western Macedonia transformative actions occur simultaneously with actions of resistance and adaptation, whereas in Silesia, resistance actions were much more present in the first period, practically absent in the second, and returned to the surface in the third period, in which the miners' unions are reactivated in the face of the political contingency of a possible mine closure. In general, we observe that, while energy workers might be sensitive to arguments (economic and political, especially) that depend on historical and political contexts, they only stop protesting when an agreement on activity cessation or phase-out conditions is negotiated and concluded. This is consistent with research on just transitions from its 1970s origins (Eisenberg, 2019).

Resistance actions are still common in later phases but rather target the development of renewables, especially wind power, usually on aesthetic (impact on landscape), health (acoustic pollution), or economic (loss of property value) grounds. In both Germany and Western Macedonia, where significant renewables developments were proposed or underway, we observed public protests. Resistance to renewables development is common (Sovacool et al., 2022) and active citizen participation and engagement is often proposed as a solution (Ziouzios et al., 2021; Owen et al., 2022). This is something we saw all regions starting to pursue toward the end of the data collection period. For example, Estonia held open Vision Days for a Fair Transition, Greece held open online consultations on its transition bill, and Poland conducted public consultations on its environmental impact assessment policy. Adaptive and transformative actions appear more frequently in Phase 2 and presumably will dominate in Phase 3 as the new system consolidates. More specifically, adaptive strategies predominate in Phase 2, when incumbent fossil systems are declining but industry is trying to keep them alive and avoid destabilisation; however, transformative strategies are also adopted in late Phase 2, depending on regional and national political priorities, energy mixes, and the actions of old and new energy players.

7.1. Alignment between scales, actors, and levels

From the analysis of our four cases, it appears that in early phases there are timid attempts by national governments to divest gradually from coal in response to EU interventions that reduce the profitability of industry. These attempts are met with diverse degrees of opposition by local/regional mining sectors – workers, trade unions, public and private industrialists, and often local authorities – generating a tug-of-war with national governments and slowing transitions for a time (longer in the case of regions where mining unions are particularly strong). In the longer term, if national governments have enough political clout, and are supported by adequate international policies, they generally overcome, or reach compromises with, local opposition.

Renewables industries in carbon intensive regions are typically hindered by national governments in early phases of transition but are later supported by the gradual development of sector regulations and the materialization of investment opportunities. However, as the NR-W example shows, significant growth in renewables infrastructure does come at the cost of heightened citizens' sensitivity to further expansion. Environmental NGOs tend to operate across scales and advocate coal phase-out, just transition, and welfare policies for workers; however, their stance is more variable with respect to the deployment of renewable energy infrastructures, which some oppose, and others favour.

The position of civil society – here meaning the general citizenry and community-based organizations but excluding NGOs – is more context-dependent than for other actors, and general trends for movement between phases are harder to derive. Early in transitions, civil society in carbon intensive regions tends to work to preserve coal industries out of concern over job losses and a loss of identity (Sanz-Hernández, 2020), while at later stages and in the presence of economic redevelopment and workforce training assured by higher levels, this position becomes more open to change.

A further finding is that the election of a party or coalition with a certain pro-/anti-transition agenda is no guarantee that transition policies will/will be implemented or even initiated, not only because of the interference of national and continental agendas but also because transition processes take longer than an electoral cycle. For example, Poland, with right-wing national and regional governments, pushed back against transition and tried to preserve several economically viable coal mines, but ultimately bowed to EU regulations on coal phase-out to retain JTF funding. In Estonia, a similar national-continental dispute over oil shale is in progress. This demonstrates the importance of binding commitments and political steering from higher jurisdictions, as well as fiscal and policy incentives for decarbonization.

7.2. Enabling movement between phases

Regions that have a clear plan for workers' transitions with funding attached are at an advantage in progressing to further transition phases. This highlights the fundamental importance of the JTF for demonstrating a concrete financial commitment to national and regional transition plans, even though JTF allocations were often mentioned in the newspapers in Silesia, Ida-Virumaa and Western Macedonia, but not the case in NR-W, possibly because the European Regional Development Fund managing authority submitted the 2021-27 JTF program for the region to the European Commission for approval only in November 2021 (the approval took place in June 2022).[8] However, each region had one or more triggers beyond the JTF for kickstarting the transition: Western Macedonia had the financial crisis in 2007; Ida-Virumaa had EU emissions policies; Silesia, had the increasing economic unviability of coal mining; and, NR-W experienced ongoing decarbonisation, and pressure from civil society and the domestic renewables industry. This indicates that context matters and there will be no one-size-fits-all solution for

[8] NR-W Economics Ministry, "ERDF/JTF program North Rhine-Westphalia 2021–2027", undated (https://www.efre.nrw.de/europaeische-kohaesionspolitik-ab-2021/efre/jtf-programm-nrw-2021–2027/).

triggering substantive decarbonisation. However, movement to further stages is enabled by the presence of EU deadlines and funds.

Moreover, when transition plans are subject to wide participation, the process appears smoother – although not necessarily slower, as one may think – than with top-down processes. The Coal Commission and the ZRR in NR-W are cases in point. The top-down development of wind farms in Western Macedonia and Germany, and the protest they generated, provide evidence that top-down decision-making also does not necessarily produce rapid transitions if key societal spheres are not aligned. This is consistent with evidence from a wide range of fields that examine participation in decision-making and social acceptance and find that, while some decisions can be made without broad input, most benefit from wider participation in terms of both decision quality and reduced objections (e.g., environmental assessments (Glucker et al., 2013), resource governance (Reed, 2008), social acceptance of renewables (Langer et al., 2017)). This finding also complicates calls for aggressive, top-down decision-making to advance decarbonisation, as has been problematised by critiques about the effectiveness and democratic quality of such strategies (Patterson et al., 2021). A synoptic view of our periodisation is found in Table 5.

Within our cases, we found that regions that are smaller, characterised by a less diversified power mix and a higher dependency on a single national resource tend to transition more slowly. Estonia's dependency on Ida-Virumaa's shale oil and Poland's dependency on Silesia's coal are examples of that. Germany is an example of a larger region with a more diversified energy mix, where dependency on NR-W's lignite is less critical. Generally, it is easier to move between phases when economies are already diversified and when the transition is already ongoing. We believe this may be common beyond our cases and this causal mechanism is likely to be found elsewhere.

Historical and cultural specificities are also important. For example, Germany has decades of experience transitioning. In comparison, a decades-long reliance on an industrial "monoculture" in Ida-Virumaa is causing political inertia, as is the symbolic value of coal as *the* resource for independence in Polish history, combined with the historically high number of miners in the Silesian region. This reinforces the argument that a region that is faring economically better will not automatically be at an advantage in the transition if it has a powerful incumbent fossil industry. Currently, Silesia's economic situation is more stable and prosperous than Western Macedonia's, and its economy is more diversified. Yet, because of its strong fossil industry, the former is experiencing significant delay in transitioning.

8. Conclusion

In conclusion, this article periodises the energy transition process in four coal-intensive European regions, based on the existing literature on just transitions and on transition phases. This complexifies the linear view of transition – and just transition in particular –, showing how strategies of resistance, adaptation and transformation do not necessarily occur in sequence and movement between transition phases is not smooth. A country or industry keen on developing renewables may work to expand fossil fuels at the same time. It is also evident that political and economic triggers are necessary, but not sufficient, conditions for the transition from one phase to another. This further depends on the historical context, economic diversification, and external variables. Our findings help to understand potential transition pathways in different regions, and better support contextually appropriate transition conditions. For transitions to be just, we show, all these factors, as well as constraints stemming from the temporal evolution of the local, regional, and national energy systems, need to be considered.

Future research could take deeper just transitions perspectives and provide more detailed insight into who undertakes which strategies, and with what consequences for both decarbonization, and for justice related issues of equity, social acceptance, and autonomy. It could also expand the geographical scope by including other regions in the process of transition.

The Russian invasion of Ukraine, occurring after our data collection concluded, has redefined the political priorities of EU member states, altering many transition plans. For countries dependent on Russian energy, governments decreased or suspended imports, replacing fuels by diversifying import strategies, returning to domestic fossil fuel extraction, or reducing demand (Kuzemko et al., 2022). As REPowerEU shows, the EU has taken action to minimise geopolitical vulnerability by diversifying energy supplies, introducing gas and oil price caps, aiming to double the deployment of renewables, and improving energy efficiency. However, support for gas, if not coal, has also rebounded. In June 2022, just after the EC's President, Ursula von der Leyen, warned about the risk of "backsliding" into coal, the European Parliament declared investments in gas (and nuclear) "green". This means that the international pressure that has driven coal phase out cannot necessarily be relied upon to advance to later transition phases. New national or international forms of motivation may be needed.

CRediT authorship contribution statement

Roberto Cantoni: Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Marie Claire Brisbois:** Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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