



Policy action for green restructuring in specialized industrial regions

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Abstract

Combining insights from evolutionary economic geography and socio-technical transition studies, this article provides a conceptual framework and a theory-informed empirical analysis of policy dimensions for regional green restructuring. The combination of these two perspectives allows the application and confrontation of analytical concepts with the particularities of regions, with a specific focus on the role of policy to ensure directionality. Empirically our discussion is illustrated by a case study of Western Norway, a specialized industrial region. We focus on the role of policy for the development of new green technology pathways within this region. We observe that different industry transition pathways within a region are influenced by various combinations of policy action, and that policy for regional green restructuring includes complex policy mixes initiated at different levels of governance. Our framework provides a suitable scheme for assessing the role of policy for green restructuring in regions.

Keywords

Evolutionary economic geography, green restructuring, policy dimensions, regional industry development, socio-technical transition studies

Introduction

Burning fossil fuels, growing greenhouse gas emissions, and a steady increase in the global temperature all call for a green restructuring of current economic systems. Many scholars have argued that innovation policy (Fagerberg, 2018) is essential to making the shift toward regional industry structures that are both economically sound and more environmentally

sustainable (Njøs et al., 2020). Various studies have investigated how these restructuring processes may occur within industries and regions, through, for

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example, downscaling non-sustainable industries, greening existing industries, or a rise in new, more environmentally friendly industries (Fløysand and Jakobsen, 2017; Trippel et al., 2020). However, we lack a comprehensive understanding of the role of policy in green regional industrial restructuring. Combining insights from evolutionary economic geography (EEG) and the socio-technical transition approach, this article provides a conceptual framework and a theory-informed empirical case for the analysis of the role of innovation policy in driving green restructuring in specialized industrial regions.

EEG scholars have been mainly concerned with understanding how regional economies evolve over time, arguing that industrial development trajectories are linked to past choices and that the scope of policy action is largely conditioned by former practices and choices within regional contexts (Martin, 2010). Although exceptions exist, EEG-inspired policy prescriptions for restructuring have been limited to efforts to improve the performance of regional innovation systems rather than to actively transforming them toward more environmentally sustainable states (Gibbs and O'Neil, 2014; Njøs et al., 2020). Large-scale transformations of regional economies are seen as not only rare but generally initiated by external shocks such as a sudden fall in market demand or other macro-level changes (Isaksen and Jakobsen, 2017; Martin, 2010).

The literature on socio-technical transitions, on the contrary, brings a more comprehensive understanding of policy directionality toward industries that are both economically sound and more environmentally sustainable. It argues that a specific orientation for industry development is needed, and that policy plays a key role in ensuring systemic change (Boschma et al., 2017; Schot and Steinmueller, 2018). However, despite this specific focus on the directionality of change, socio-technical transition studies and their policy prescriptions have been criticized for promoting a generic, "place blind" approach to restructuring (Uyarra et al., 2019). Specifically, the literature lacks sensitivity and attention to the spatiality and context-specific factors shaping transitions (Binz et al., 2020).

Herein, we combine EEG and socio-technical transition studies to develop a conceptual framework

for policy action in supporting green restructuring. EEG helps us understand how restructuring unfolds in different regions and how existing industrial structures influence these processes (Martin, 2010). Socio-technical transition studies, on the contrary, provide us with a strong rationale for integrating environmental considerations in regional restructuring studies (Markard et al., 2012). The combination of these two perspectives allows the application and confrontation of analytical concepts with the particularities of regions, with a specific focus on the role of policy to ensure directionality (Fastenrath and Coenen, 2020; Gong and Hassink, 2020; Uyarra et al., 2019). However, since both literatures lack sufficient understanding of how to operationalize policy dimensions for green restructuring in a regional context, our article intends to address this gap. This is important because such restructuring requires novel policy initiatives and tools facilitating comprehensive changes to both firms' strategies and the regional industry mix. It also relates to the recent attention to agency in both EEG and socio-technical transition studies (Geels, 2020; Grillitsch and Sotarauta, 2020), and we intend to add to this topic through a specific focus on the relatively neglected agency of policy actors in relation to green restructuring (Uyarra et al., 2017).

Our article focuses on policy action supporting green restructuring in specialized industrial regions, and empirically our discussion is illustrated by a case study of Western Norway (including the counties of Rogaland and Hordaland). This is a specialized industrial region with a dominant position in the Norwegian petroleum sector. Norway is a vital oil and gas supplier to the global market; crude oil, natural gas, and condensate constitute close to 50 percent of Norway's export value. Western Norway is by far the most important region for the nation's petroleum sector, accounting for 56 percent of these jobs (Samfunnsøkonomisk analyse, 2017; Vatne, 2018). Fluctuating oil prices and the long-term grand challenges of greening the economy present the region with a double challenge: develop a more diverse, less oil-dependent regional economy while ensuring that this restructuring involves a shift toward greener, more environmentally sustainable economic practices. Thus, our study is based on the following theory-informed research questions:

Research Question 1: How can EEG and socio-technical transition studies inform our understanding of the role of policy in green industrial restructuring in regions?

Research Question 2: What is the role of policy for green restructuring in Western Norway?

Research Question 3: How can the combined literatures from EEG and socio-technical transition studies inform policy formulation for green regional restructuring?

The next section presents our theoretical approach. Our brief introduction to the concepts of restructuring and directionality within both EEG and socio-technical transition studies is followed by the introduction of a conceptual framework for the policy dimensions which, according to these literatures, are necessary for promoting regions' green industrial restructuring. The framework is illustrated by a case study of green restructuring in a specialized economic region. We focus on the role of policy for the development of new green technology pathways within the three main sectors in the region: the development of battery technology within the maritime sector, the development of new sustainable salmon aquaculture technology within the seafood sector, and the introduction of carbon capture and storage technology (CCS) within the petroleum sector. This is followed by a discussion of policy for regional green restructuring informed by both theory and empirical observations.

Theoretical approach

Regional restructuring processes

Three main approaches can be identified within EEG—path dependence theory, generalized Darwinism, and complexity theory (Boschma and Martin, 2010). We are mainly informed by the former tradition, which studies how regional economies evolve over time, taking the view that restructuring is associated with continuation and gradual change (see, for example, Martin, 2010). Attention has been given to the roles of industry structures, competence, networks, policy tools, and institutional setups in investigations of regional development patterns. Studies have typically focused on regional

development trajectories, that is, how industry paths are created, modified, and, in some cases, ceased to exist (Grillitsch et al., 2019). Broadly speaking, this research “. . . values geographical differences in the sense of assuming economic action to be contextual rather than driven by a maximization calculus” (Hassink et al., 2019: 1637). EEG-inspired policies have primarily sought to improve the performance of the regional innovation system, rather than consider the direction of change toward, for example, green industrial activities. Smart specialization policy, with EEG as its main influence, calls for policy strategies that selectively build on regions' strengths and capabilities, and stimulate regional restructuring by promoting relations between technologically related industries (Foray, 2015). However, smart specialization policy, and its focus on the diversification of existing regional industries, has been criticized for promoting “more-of-the-same” and for lacking a focus on more radical transformation (Hassink and Gong, 2019; Uyarra et al., 2020).

In contrast, socio-technical transition studies specifically seek to understand the sustainability challenges across different sectors of a society, and how to combine economic and social development with reduced environmental pressure. This perspective focuses on socio-technical systems consisting of actors, institutions, technologies, markets, and policies, and development is argued to take place through the coevolution of these dimensions (Geels and Schot, 2007; Markard et al., 2012). Moreover, since a complete transformation may take decades, this literature focuses on long-term development processes. For instance, unlocking an established industry system characterized by a strong degree of path dependency takes time. The socio-technical transition studies' perspective also states that transition processes are characterized by open-endedness and uncertainty. There are multiple transition pathways within a system, so it is difficult to predict which initiatives will succeed long term (Rosenblom, 2017).

Hence, the literature on socio-technical transitions has sought to unpack the deep structural changes required in socio-technical systems to ensure greater sustainability, including radical reconfigurations in firm practice, technologies, and institutional setups. Analytically, transition studies focus on niches, regimes, and landscapes to explain greening processes.

The emphasis is on the role of (technological) niches. Niche innovations are unstable configurations with a minor market position which, through interactive learning and given the right conditions, can build up momentum and achieve support from powerful groups. Niche innovations are thus vulnerable during their early introduction, needing policy to build a “protective space” that shields them from strong competition from existing and dominant technological solutions (Smith and Raven, 2012). This can eventually alter the “rules of the game” and advance the socio-technical regime (Geels and Schot, 2007). However, this perspective has been less concerned with how transition processes unfold in different regions, and the spatial interplay between niches, regimes, and landscapes (Coenen et al., 2012).

Thus, it emerges that green regional restructuring efforts require more than EEG’s focus on technology and knowledge diversification and can benefit from broader insights from transition studies regarding innovation policy intervention. Combining EEG and socio-technical transition studies, Trippel et al. (2020), for instance, argued that regional characteristics shape opportunities for sustainable or green industry development.¹ Likewise, Grillitsch and Hansen (2019) argued that there is a clear connection between the industrial composition of regions, and opportunities for green diversification and restructuring. Specialized industrial regions may have a strong traditional industrial presence (e.g. the petroleum sector), implying that it is challenging to develop clean technologies in these locations. Specialized industrial regions also tend to have R&D institutions and support systems that are closely aligned with the dominant industry, making them vulnerable to negative lock-in and strong contestation from incumbent activities. As Grillitsch and Hansen (2019) noted about these regions, the most realistic restructuring strategy is to focus on the greening of existing industries and green diversification (i.e. use existing competences to diversify into new, green(er) industries).

The importance of policy for directionality

Inspired by socio-technical transition studies, the emerging “transformative innovation policy”

paradigm (Fagerberg, 2018) argues for a “normative turn” and clearer directionality to provide outcomes that benefit society. Similarly, “mission-oriented” policies have been proposed for tackling specific societal challenges such as battling climate change. Such policies require well-defined missions and top-down coordination among various actors and sectors, as well as bottom-up experimentation and learning, and development of dynamic feedback loops (Mazzucato, 2018). From this perspective, innovation policy should not only stimulate competitiveness and value creation, it should also guide development toward desired societal goals. Some scholars have noted a lack of attention to contextual factors and scalar sensibility of transformative and mission-oriented innovation policy approaches, and thus questioned the suitability to inform policy decisions for green restructuring at the regional level (Coenen et al., 2012; Wanzenböck and Frenken, 2020). Against the implicit assumption that societal challenges are global and thus best dealt with at the national or supranational level, Wanzenböck and Frenken (2020) stress the need to acknowledge the contextuality and place sensitivity of societal needs, and the multi-scalar embedding of societal problems.

The idea of directionality suggested by these approaches refers to “the necessity not just to generate innovation as effectively and efficient as possible, but also to contribute to a particular direction of transformative change” (Weber and Rohrer, 2012: 1042). It suggests that collective policy priorities, in the form of shared visions, strategies, and agendas, are needed to orient or guide policy efforts toward green industrial restructuring. Directionality represents, according to Miörner (2020), a form of institutionalized expectations that defines the frame of engagement of regional actors, redefining the boundaries of what deserves attention and what doesn’t. It is thus not “taken for granted but continuously contested within and across actors in the region” (Miörner, 2020: 5). Given the context specificity of societal needs and challenges, priorities would be framed and interpreted differently in different regions, and thus present key policy—and political—challenges around problem definition and identification (Uyarra et al., 2020).

According to transformative innovation policy approaches, system-wide transformation also requires attention to experimentation, demand articulation, and policy learning and coordination (Weber and Rohracher, 2012). For instance, Grillitsch et al. (2019) suggest that these domains can be linked to the key innovation system dimensions of actors, networks, and institutions to support the design and implementation of innovation policy for system-wide transition. Taking this to the regional level, policy stimulating green regional industrial restructuring requires a vision or direction that guides policies to actively prioritize the following: promote the greening of existing industries; prioritize the development of new green industries instead of development of less-sustainable industries; demonstrate how green technological niches can replace the incumbent “dirty” versions; demand articulation that can shift the selection environment by providing incentives and reducing the risk for the adoption of new, more sustainable, solutions; develop policy capacity to learn from experimentation; and ensure multi-level and multi-actor policy mixes coherence for green restructuring (Matti et al., 2017).

The need for agency

Directionality is necessarily linked to human agency, namely, how actors intervene to create, recreate, or alter development paths (Mackinnon et al., 2019). According to Miörner (2020: 5), the alignment of existing visions, strategies, and agendas will influence “the frame of engagement for actors, promoting change processes along a narrow trajectory centred on a specific set of issues.” Directionality is shaped by and shapes how actors formulate strategies toward changing or reconfiguring elements of the innovation systems and how they navigate the system and adapt their activities.

To understand policy interventions promoting regional green restructuring, there is therefore a need for a better understanding of agency, and particularly the agency of policy actors (Borrás and Edler, 2020; Dawley et al., 2015; Njøs et al., 2016). According to Borrás and Edler (2020), system transformation requires the consideration of multiple and diverse roles of the state beyond a narrow market correcting

one, including as facilitator, lead user, enabler of societal engagement, gatekeeper, promoter, moderator, initiator, and guarantor.

Linked to the topic of this article, our focus is on agency by political and administrative actors involved in developing and implementing policy tools, and how they, through deliberate action, facilitate the agency of firms and non-firm actors that ultimately contribute to regional economic restructuring. However, and importantly, this involves not just policy makers but “a multiplicity of actors, state and non-state, individual, networked and corporate,” may be involved in shaping policy (Flanagan and Uyarra, 2016: 178) and the setting of “directionality.” This also includes the activity of intermediaries working to create favorable conditions for regional innovation (Njøs et al., 2016), for instance, key personnel of cluster organizations that are part of national or regional coordinated public-funded cluster programs.

Grillitsch and Sotarauta (2020) have identified the main forms of change agency that can shape the regional restructuring process. Innovative entrepreneurship is associated with the Schumpeterian entrepreneur discovering and exploiting new possibilities and this is mainly performed by firms and other economic actors. However, other types of change agency are more closely connected to agency carried out by policy actors to change or alter the existing support system. Institutional entrepreneurship is about seeing the opportunity to change institutions and institutional setups and taking the risk of doing it. Such agency can, for instance, deliberately change the rules of the game by introducing new political regulations having a huge impact on the practice of industry actors. Place-based leadership is more regionally embedded and captures action aimed at transforming and changing regional development paths through mobilizing regional competence and resources. Sotarauta et al. (2020) also underline the importance of the agency of support actors, such as regional intermediate organizations that support, facilitate, and coordinate change efforts (Isaksen and Jakobsen, 2017). These actors may not change the policy setup or the rules of game, but they provide other regional actors with a supportive environment.

In addition to recognizing the type of agency that is needed by policy actors, we also need to acknowledge under which conditions “directional” change agency can be performed. Roberts and Geels (2019) find that policy actors can decisively accelerate socio-technical transitions, but their ability, willingness, and prospects for promoting changes depend on several temporal conditions. This includes both socioeconomic and policy regime factors. Examples of the first are price and technology improvements resulting in the successful introduction of green niche innovations, key industrial actors seeing rising possibilities for green solutions, a growing dissatisfaction among customers with existing solutions, and public debates promoting and legitimizing green and alternative solutions. Examples of the second type are external push for the inclusion of green requirements in national policy frameworks, a rearrangement of the national–regional policy setup and distribution of responsibilities, and the entrance of new powerful actors at the policy scene. In tandem, these factors may form a specific “opportunity space” for deliberate change agency by visionary policy actors (Grillitsch and Sotarauta, 2020). Such opportunity space is a temporal and context-specific phenomenon, and certain moments in time and certain regional and national conditions are more advantageous for deliberate change agency than others.

Directionality and policy implementation in regions are a complex process meriting further attention (which goes beyond the remit of this article). Implementation of these types of policies may suffer from potential weaknesses, such as unclear rationales for intervention (Rodrik, 2008), insufficient policy levers, lack of capacity of policy actors, or poor horizontal and vertical coordination. Regional green restructuring would be influenced by policy action initiated by actors at the regional-, national-, and even the international levels, through, for example, innovation and environmental policies, regulatory and legal action, taxation policy, and the introduction of different standards and requirements. Many of these policy interventions are beyond the reach of policy actors in regions, and thus often lack sufficient levers to influence regional restructuring. Sometimes regional policy action is relegated to

playing a compensatory or supporting role for decisions taken at other levels of governance (Uyarra and Flanagan, 2010); however, regional initiatives can also influence national policies (Sjøtun, 2019). Thus, understanding the different levels for policy intervention and the interdependency and (lack of) coordination between them is key to identifying the complexity of policy action for green regional restructuring (Jakobsen et al., 2019; Steen and Hansen, 2018; Uyarra and Flanagan, 2010). Coordination efforts are not straightforward and unproblematic, but are likely to expose key political tensions and trade-offs. However, the focus of this article is not to discuss political contestation and how and by whom directionality is shaped, that is, the “opportunity space,” but rather to assess requirements for policies for green restructuring of specialized industrial regions (see Grillitsch and Hansen, 2019).

Toward a conceptual framework

As discussed above, directionality means articulating policy goals and strategies that prioritize the development of capabilities, networks, and institutions that facilitate a specific orientation for regional industry development. In our case, directionality toward a more environmentally sustainable regional industry mix. Building on EEG and socio-technical transition studies, we found that socio-technical transition studies emphasize policy experimentation, market nurturing, and policy coordination, while EEG has a strong focus on the importance of reconfiguring existing regional industrial resources. There is also a focus within EEG on the multi-scalarity of policy (e.g. interactions between regional, national, and international policies) and the need for a coordinated policy mix (Matti et al., 2017). Hence, based on the discussion above, we argue that policy action for green restructuring can be operationalized through four dimensions: experimentation, market nurturing, resource reconfiguration, and coordination.

Policy experimentation. There is no quick fix or blueprint for green restructuring. Within socio-technical transition studies and transformative innovation

policies, there are calls for “experimentation” to design, test, and trial new institutional solutions and partnership types (Laplane and Mazzucato, 2020). The idea of experimentation can also be linked to the broader discussion of policy innovation, that is, a type of innovation that aims to respond to wicked and unruly problems to realize an ambitious new policy agenda (Torfing and Ansell, 2017). This includes redefining policy problems, reformulating policy goals, and developing novel strategies and policy tools. Moreover, strategic niche management (SNM), which is central to transition studies, promotes policy innovations and experimentation by constructing temporary spaces in which policy and industry actors work together on a variety of initiatives (Schot and Geels, 2008). Newer contributions within EEG also argue for policy experimentation as open-ended, with an emphasis on bottom-up learning to negotiate definitions of local problems and understandings, as well as adaptive policy implementation to respond to them (Flanagan and Uyarra, 2016; Wanzenböck and Frenken, 2020). Thus, policy learning and forming new networks and policy arrangements are key elements within policy experimentation (Fastenrath and Coenen, 2020; Schot and Steinmueller, 2018).

Market nurturing. It is difficult for new green products to compete with established products and solutions. Markets for certain technologies may not exist due to uncertainties around customer needs, lack of standards, or uncertainty about costs and benefits (Bergek et al., 2008). Thus, especially in the early phase of green market development, there is a need for market nursing through governmental initiatives, such as protected spaces for new products or specific tax regimes. Demand articulation, for instance, through public procurement, is likely to help the development and adoption of new technologies by influencing the size, sophistication, and direction of demand (Uyarra and Flanagan, 2010). While socio-technical transition studies have acknowledged the role of policy for creating green markets, it has been argued that EEG studies largely ignore the notion of demand (Martin et al., 2019), and Grillitsch et al. (2019) stressed the importance of demand articulation and the need to learn about users’ needs. A specific challenge that might be

leveraged by policy initiatives is identifying and supporting lead users of new green technology and, more generally, stimulating producer–user interactions. Another relevant issue is the need to build competences for innovation procurement among public sector actors (Uyarra et al., 2020).

Resource reconfiguration. Industrial development in specialized regions is characterized by a strong degree of path dependency. Firms’ technological capabilities and the skills of individuals reflect regions’ historical development. These resources are also important for new product development and industrial activities, which can be stimulated by restructuring processes. Thus, existing resources must be harnessed and valorized to fit new practices, and policy plays an important role in facilitating these processes. Regions have a broad range of assets or resources that can be mobilized, improved, and legitimized, including natural resources, physical infrastructures, industrial resources, human resources, and institutional endowments (MacKinnon et al., 2019). In addition to reusing existing resources, policies directed at green restructuring may promote the creation or importation of resources new to the region, both endogenously and by linking with supraregional processes (Tripl et al., 2020).

Policy mix coordination. Green restructuring requires the alignment of a broad mix of policy instruments at multiple domains (not just innovation policy but other areas such as planning policy or energy policy) and governance levels (e.g. regional, national, and international) (Matti et al., 2017). Initiatives directed at firms and industries are needed, as are initiatives intended to strengthen R&D institutions, innovation support structures, and linkages between regional and non-regional actors. The policy mix notion conjures the need to attend to potential interactions, conflicts, and tensions among goals, targets, rationales, and implementation of different policy instruments (Flanagan et al., 2011). It also emphasizes policy coherence, namely, a consideration of complementary or synergistic factors across instruments at different governance levels and potential misalignments between policy design and implementation. Temporal coherence and policy mix stability over time are also important (Rogge and Reichardt, 2013).

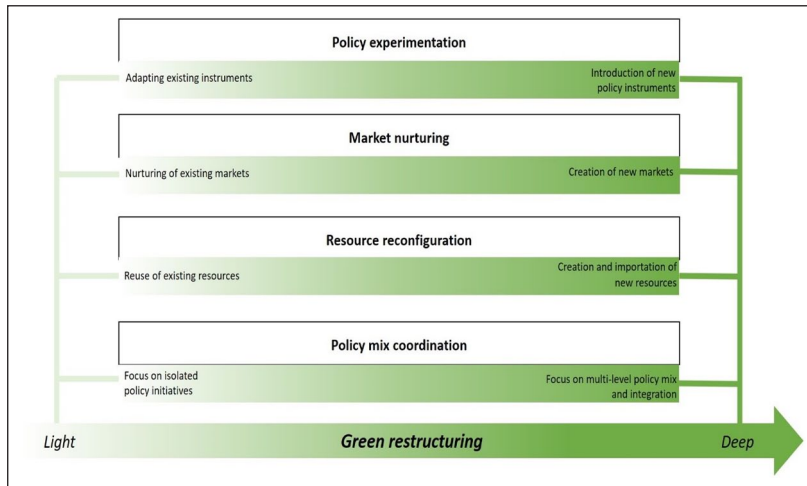


Figure 1. Policy dimensions for green industrial restructuring.

Cumulatively, the four policy dimensions, and how they are linked to temporal and place-based conditions, provide a framework for assessing the greening potential of policy action directed toward regional industrial restructuring. In Figure 1, the potential outcomes of policy intervention for green restructuring are presented on a continuum from light to deep green. It is apparent from Figure 1 that policy initiatives targeting minor policy experimentation (adaptation of existing instruments), a low degree of market nurturing, reuse of existing resources, and a lack of policy coordination between different initiatives provide trajectories toward light green restructuring. Conversely, a high degree of policy experimentation emphasizing the introduction of novel policy instruments, nurturing of new markets, creating and importing new resources, and an efficient coordination of regional and extra-regional policy initiatives represents a strong degree of change agency and a potential route toward a deep green restructuring. From a regional perspective, a deep green policy approach is a high-risk–high-gain strategy, whereas a light green strategy involves small steps and gradual restructuring, with less risk of policy failure.

The greening of sectors and industries within a region is necessarily influenced by different policy initiatives and strategies. Some policies will be

initiated by national authorities, others by regional authorities; some will be sector-specific, while others will be more industry-neutral. For instance, it is likely that there will be empirical examples of regions in which some industries are exposed to policy initiatives encouraging radical changes, while other industries are mainly exposed to policies encouraging minor changes. A region's restructuring outcome emerges from the combination of different industrial transformation pathways.

Following from the discussion herein regarding specialized industrial regions, theory leads us to expect that regions specialized in traditionally non-green industries will be biased toward light green strategies, while more diversified regions or those with a foothold in green industries will lean more strongly toward deep green strategies (Grillitsch and Hansen, 2019; Isaksen et al., 2019). On the contrary, it is also argued that specific temporal conditions may provide an opportunity space for policy actors to accelerate green restructuring, even in regions specialized in non-green industries (Roberts and Geels, 2019). In the following section, we demonstrate our conceptual framework through a case study of a specialized industrial region, emphasizing how place-specific conditions influence on how policy initiatives for green restructuring play out in regions.

Empirical analysis: the case of Western Norway

Methodology, data collection, and case description

Our study focuses on Western Norway, a region in which the petroleum sector is dominantly positioned. We anticipated that a focus on an oil-dependent region would pinpoint the need for directional agency by policy actors to ensure a green restructuring. A case study also gives us a possibility to examine how the development in a specific region may have a broader theoretical relevance (George and Bennett, 2005). The analysis is based on qualitative interviews, recent studies, and document analyses. Industry analysis and policy documents were used to get an overview of the development in the region. Here, we observed that much of the ongoing greening in the region was linked to the three main sectors: seafood, maritime, and petroleum. During 2018/2019, we conducted 15 qualitative interviews with key regional actors in Hordaland and Rogaland, including representatives from industry cluster organizations, R&D organizations, regional authorities, financial organizations, and leading firms. Informants were selected based on their expertise and insight into industry development and green regional restructuring. We also ensured that we included informants that were well informed about the development of the three main sectors in the region. In the interviews, we used a semi-structured interview guide that emphasized regional development trends, examples of green restructuring, the role of policy for restructuring, and the informant's perception of opportunities and obstacles for green restructuring. Each interview lasted between 45 minutes and 1½ hours, and they were all recorded and transcribed. Data from the interviews were categorized in accordance with the main topic of the interview guide. Moreover, we have also revisited recent studies of greening efforts within the three main sectors. Our analysis is part of a larger research project (Drivers for regional restructuring), and other parts of the project have conducted industry-specific studies. More specifically, we draw from Isaksen et al.

(2019) and Lindfors (2019) in our analysis of the greening of the seafood sector, from Njøs et al. (2020) in our analysis of greening within the petroleum sector, and from Sjøtun (2019) when investigating the maritime sector.

Western Norway includes Hordaland (with 505,000 inhabitants) and Rogaland (with 473,000 inhabitants) counties (Figure 2). The petroleum sector is enormously important to Norway's economy, and is critical to the economy of Western Norway, mainly due to the region's proximity to several important oil and gas fields in the North Sea. Norway is a vital global market oil and gas supplier, with the export value of crude oil, natural gas, and condensate representing 475 billion NOK in 2015, close to 50 percent of Norway's total export value. Approximately two-thirds of the total Norwegian export of crude oil, natural gas, and condensate were generated from Western Norway (Samfunnsøkonomisk analyse, 2017; Statistics Norway, 2020). The region's total turnover for the petroleum sector was 515 billion NOK in 2015. The sector also generates many jobs; in 2015, the total number of full-time jobs in Western Norway's oil and gas sector was 58,989, including both extracting and supplying goods and services. The region's overall national importance is illustrated by the fact that 56 percent of jobs within the petroleum sector in Norway are in this region (values for 2017, see Vatne, 2018). Other important sectors in this region include maritime and seafood, the latter being particularly export oriented. In 2015, the total turnover of the maritime and seafood sectors was 76 and 32 billion NOK, respectively, while the numbers of full-time jobs were 25,064 and 6,981 respectively (Samfunnsøkonomisk analyse, 2017). The region's R&D system is particularly focused on the petroleum, maritime, and seafood industries (e.g. University of Bergen, University of Stavanger, Western Norway University of Applied Sciences, The Institute of Marine Research, Norwegian Research Centre (NORCE)); however, R&D intensity naturally varies among these regional industries. In addition, public actors and agencies relevant to the petroleum industry, such as the Norwegian Petroleum Directorate, are present in the region.



Figure 2. The case region of Western Norway.

Green industrial restructuring in the region

The role of policy for ongoing greening within our case region will be analyzed in accordance with our four policy dimensions for green industrial restructuring (experimentation, market nurturing, resource reconfiguration, and policy coordination). We focus on the role of policy for the development of new green technology pathways within the three main sectors in the region: the development of battery technology within the maritime sector, the development of new sustainable salmon aquaculture technology within the seafood sector, and the introduction of CCS technology within the petroleum sector. By emphasizing the development of new green technology pathways within different sectors, we aim not only to illustrate how the role of policy for restructuring may differ between various sectors within a region but also to observe sectoral specificities. However, we start with a more general consideration of the role of policy for regional industrial development.

Policy background. Ongoing green restructuring efforts in Western Norway have been influenced by a complex mix of policies at the global, national, and regional levels. Some policies are directed toward R&D and innovation generally, while others are more industry specific. Of necessity, some policies are also more targeted toward promoting sustainability and green development. The most influential policy domain in our case region is the national petroleum policy. The petroleum policy includes taxation policy, the Petroleum Act, and a system for resource management. The latter involves the distribution of licenses for operating existing fields and for new field discovery and development. There is still a high level of activity in new field development in Norway, indicating that, though much debated, petroleum will remain essential to the Norwegian economy for the foreseeable future (Government, 2020).

Overall, the Norwegian research and innovation policy system includes several institutions with

different, and to a certain extent conflicting, roles. Especially important are the various national-level government ministries responsible for defining the policy goals and funding research and innovations within their respective sectors. Moreover, public agencies oversee implementation of the public research and innovation policy. The most important actors in this system are the Research Council of Norway and Innovation Norway. They promote a wide range of innovation policies initiatives of strategic importance for our case region and the selected industries. Recently, there has been a growing focus on promoting green restructuring. In their strategy document, Research Council of Norway says that they intend to “pioneering research and innovation efforts for sustainability across subject fields, sectors and funding sources” and to reorient “research and innovation efforts in the five strategic areas in a more sustainable direction” (Research Council of Norway, 2020). Innovation Norway (2021) says that they have “. . . taken a proactive role in the effort of steering companies towards thinking and acting in a more sustainable way.” Moreover, there are also several examples on how these institutions have coordinated their efforts for green restructuring. One example is “The Green Platform Initiative.” The intention is to provide funding for companies and research institutes engaged in green growth and restructuring. The platform also intends to make Norwegian firms better equipped to exploit the opportunities provided by European Union’s (EU) Green Deal initiative. The government has granted 1 billion NOK for a period of 3 years (2020–2022) for this initiative for green restructuring (Meld.St.40, 2020). In addition to the Research Council of Norway and Innovation Norway, Siva (a state enterprise investing in real estate and facilities for innovation) and Enova (a public agency promoting a low carbon society) are involved in organizing and implementing the Green Platform Initiative. Another coordinating effort of importance for our case region is PILOT-E. This is organized by the Research Council of Norway, Innovation Norway, and Enova, and is a public funding scheme that intends to facilitate the development of environmental-friendly energy technologies and services (Meld.St.40). This scheme has been especially important for the greening of the maritime sector.

There are also important innovation initiatives organized at the regional level. The county administrations are responsible for carrying through, inter alia, regional development efforts. In our case, this has included the county authorities for Rogaland and Hordaland.² Among their primary objectives is promoting regional industrial development, for which they have some independent funding. These counties are also in a process of developing their own smart specialization strategies, which includes a focus on not only how to diversify the existing regional industry structure but also, and to some extent, how to promote green restructuring. There are regional funding schemes related to the implementation of the strategy, but most public funding of R&D and innovation is administered and allocated by national agencies. Overall, public funding constitutes nearly 20 percent of the total funding for R&D and innovation activity within the private sector (Indikatorrapporten, 2019).

Moreover, at the regional level, there are also several publicly funded intermediaries mobilized for R&D and innovation within, and across, different industry sectors. Especially important to our case region are the publicly funded industry cluster organizations, which are operational within several of the industries in the region, including the three main industry sectors.

The maritime sector—battery technology development. Our first example of ongoing green restructuring in Western Norway is the development of battery technology within the maritime sector. These technology systems are designed for implementing fully electric or hybrid battery and fossil fuel energy systems on ships, and/or charging technology supplying ships with electrical power. The maritime industry in Western Norway, consisting of shipyards, shipping companies, and suppliers, has a history of operating in the ferry and offshore markets. Over the past decade, they have utilized their experience and knowledge to drive development further toward green solutions.

Policy experimentation. Different national policy initiatives have encouraged the observed green restructuring, such as those initiatives by the national public agency Enova, which has contributed to the

funding of several maritime battery or electrification projects in our case region, and the national NOx Fund, into which member firms pay an emission tribute in lieu of state taxes or fees. Moreover, the county council administrations in Western Norway have demanded low- or zero-emission standards in procurements of new ferry contracts (Sjøtun, 2019). Cumulatively, these activities indicate a certain degree of policy experimentation to promote the ongoing green restructuring of the maritime sector.

Market nurturing. County council administrations in Western Norway have contributed to the nurturing of new green markets through new tenders for ferry contracts. Although these tenders have been technology-neutral, battery technology is becoming the main “response” from companies.

Resource reconfiguration. While battery technology development has been driven by global car manufacturing, visionary and purposeful regional actors have seized opportunities to implement and adapt its use in the maritime sector. This development has also been supported by regional R&D institutions, which increasingly focus on battery technology development (Njøs et al., 2020). In sum, we observe the reuse of existing resources and capabilities, the importation and adaptation of resources developed in other sectors, and the creation of new resources.

Policy mix coordination. There is a mix of policy initiatives for the greening of the maritime sector, and the regional maritime cluster organization in the region (NCE Maritime CleanTech) has also been instrumental in lobbying national and regional policy authorities to include green specifications within regulation schemes. They have also facilitated the coordination of various initiatives and ensured a common strategy for regional firms.

Greening level. The region’s maritime industry has succeeded in their greening strategies and is considered a world leader in producing and operating car ferries and offshore supply vessels using battery technology (Sjøtun, 2019). Maritime battery technologies are now finding their ways into new markets, such as short sea cruise traffic, fishing

vessels, and wellboats. Cumulatively, these activities represent an ongoing deep green restructuring of the region’s maritime industry.

The seafood sector—development of sustainable salmon aquaculture technology. Another new green technology pathway in Western Norway is the development of sustainable salmon aquaculture technology within the seafood sector. Salmon aquaculture is the main industry branch of the seafood sector in the region. There has been widespread concern in the salmon industry about negative environmental effects caused by its open net-pen technology, such as ocean floor waste, spread of diseases, fish escaping, and sea lice (Fløysand and Jakobsen, 2017). Three new green technology systems are under development within salmon aquaculture: farming systems on land, consisting primarily of flow-through systems or recirculating aquaculture systems; semi-closed or closed farming systems at sea; and offshore systems operating in exposed areas. These systems are far more technologically advanced and environmentally sustainable than existing open net-pen technology.

Policy experimentation. These new technologies have been promoted through the national government allocation of development licenses. A production license issued by the government is required in order to operate within the salmon industry; however, this is the first time that such licenses have been allocated purely to promote the development of new sustainable technology. Thus, this technology development includes a certain degree of policy experimentation. Salmon producers in Western Norway are involved in four large technology development projects initiated through these development licenses, where different technological solutions for sustainable farming technology are being tested (such as closed and semi-closed farming systems in sea).

Market nurturing. Through the introduction of these development licenses, the government has stimulated the demand for sustainable salmon aquaculture technology. This has contributed to a growing market for suppliers of equipment, production facilities, and farming systems.

Resource reconfiguration. These development projects involve both the reuse of existing resources and importation and creation of new resources. R&D institutions and suppliers, both within and external to the region, have been involved in technological development. We also observe that existing competence and technology among suppliers within the oil and gas sector in the region has been reused and adapted to the aquaculture industry's needs. Regional policy actors, especially the cluster organization NCE (Norwegian Centres of Expertise) Seafood and GCE (Global Centres of Expertise) Ocean, have been active in promoting these crossover initiatives.

Policy mix coordination. Policy coordination has been lacking, while development is driven by a single policy initiative (the government's system of development licenses). Even though regional policy actors (e.g. cluster organizations) have lobbied for policy programs for greening that would better fit the region's industry needs, they have not succeeded in their efforts.

Greening level. It remains undetermined whether these new green technologies will become economically viable, especially compared with the hegemonic open net-pen technology. If their implementation is successful, they will contribute to a greater degree of technology pluralism in the industry. Still, several other environmental concerns remain for this industry (e.g. salmon feed content), and other green policy initiatives and strategies are needed to ensure a deep greening of the industry.

The petroleum sector—introduction of CCS. The petroleum sector has recently initiated various measures to reduce its carbon footprint, including working toward improving oil and gas field recovery and plans for oil field electrification. However, an initiative that is currently high on the agenda is the development of CCS technology (i.e. technological solutions for capturing and securely storing CO₂ in geological formations). A large test facility for CCS technology was established at Mongstad in Western Norway in 2012. In the spring of 2021, the Parliament approved support for a full-scale CCS demonstration project in

Norway, a project in which Western Norway plays an important part. The full-scale project is intended to capture CO₂ from industrial facilities in Eastern Norway before transporting it to facilities in Western Norway for interim storage until it is injected into geological formations in the North Sea.

Policy experimentation. Opened in 2012, the Test Centre Mongstad was in 2007 portrayed by the then-Prime Minister as “Norway's moon landing.” It represents a public investment of approximately 7.6 billion NOK (Atkins and Oslo Economics, 2016) and, along with the full-scale project, indicates a strong willingness from national-level policy authorities to provide funding for technology development. National authorities have not been involved in the past in a similar policy-initiated project, so there is also a dimension of policy innovation and experimentation.

Market nurturing. Currently, there is no commercial market for CCS solutions. CO₂ capture and storage is expensive, and there are few incentives for commercial actors to implement the technology without public support. However, informants argue that possible changes in quota systems and new global/national regulations may trigger commercial interest in this technology. To reach that point, informants argue, the full-scale project will be of high importance.

Resource reconfiguration. According to actors in the oil and gas industry, CO₂ transportation and storage are technically viable for firms with petroleum industry experience. This means that existing capabilities, knowledge, and competence in the region can be utilized in the development and implementation of CCS, particularly for CO₂ transportation and storage. In addition, it is argued that CCS technology can enable other technological developments (e.g. hydrogen production from natural gas), which would also require regional resource reconfigurations.

Policy mix coordination. The government's CCS development efforts have been coordinated by the national public agency Gassnova. Gassnova was established by the Norwegian authorities in 2005

Table 1. The role of policy for the development of new green technology pathways.

Sector: Policy dimension	The maritime sector—battery technology	The seafood sector—sustainable salmon aquaculture technology	The petroleum sector—carbon capture and storage technology
Policy experimentation	Regional initiated ferry contracts	National initiated development licenses	National initiated test center
Market nurturing	Contract requirements set by regional policy actors, lobbying by regional policy actors toward the national level for the introduction of new technology standards	Stimulate demand for sustainable technology	Support for technological development and verification
Resource reconfiguration	Extensive, promoted by regional policy actors	Extensive, promoted by regional policy actors	Potential has not been realized
Policy mix coordination	Well-functioning national–regional coordination	Lack of national–regional coordination	Lack of national–regional coordination

to further develop CCS-related technologies and knowledge, and to serve as a government adviser on this issue. Gassnova was tasked with administering the research and financing program CLIMIT (a national program for research, development and demonstration of CCS), and with ensuring testing and developing CCS technologies at the Technology Center Mongstad.

Greening level. Informants and media reports argue that, from a Norwegian perspective, the full-scale project is important for further CCS development. The full-scale project is intended for technology verification and to demonstrate a full-scale solution for capturing, transporting, and storing CO₂. According to the plan, the new facilities could be up and running in 2024, with substantial public investments (approximately 17 billion NOK in a total budget of 25 billion NOK).³ Although CCS is a debated climate mitigator, it has been promoted by the EU as a key solution for meeting the Paris Agreement, signed in 2016 (e.g. by mitigating emissions from process industries). Thus, it can be argued that CCS holds strong policy potential for developing a deep green technology solution. On the contrary, reducing the carbon footprint from gas extraction through better technology for CO₂ capture and storage via CCS, as well as the potential for using CCS technology for emission-free “blue hydrogen” production—for example, hydrogen produced from natural gas may contribute to extending the region’s dependence on

the oil and gas sector. This increases contestation of the greening effects of CCS.

Discussion

To explore how policy can promote green restructuring and the development of new green technologies, we have introduced a framework consisting of four dimensions. In the previous chapter, we have discussed how policy initiatives for green restructuring in our case region fit with these dimensions by analyzing new green technology pathways within the three main sectors in the region. We found our analytical framework suitable for assessing the role of policy actors for the development of these new green technology pathways. We also found that the role of policy differs between the technology pathways under development in the region. Table 1 summarizes our findings from the case study.

The first requirement for green restructuring is the need for policy experimentation, that is, the development and implementation of new innovative policy initiatives. In the case of Western Norway, a certain degree of policy experimentation can be observed in the development of new green technology pathways. One example, linked to the agency of regional policy actors, is the county council administration’s role in introducing new green ferry contracts within the maritime sector. The two other examples include initiatives from national policy authorities for a new and innovative scheme for

development licenses in the salmon aquaculture and a policy-initiated test center for CCS within the petroleum sector.

The second requirement is market nurturing. Policy action can shape demand by directly or indirectly influencing the size, nature, and sophistication of new, greener markets (e.g. through regulation, standards, or public procurement). We found that when it comes to the development of battery technology within the maritime sector, there has been a strong agency by policy actors toward market nurturing. New technology standards for ferry contracts set by the county council administration promoted a market for green solutions. Other regional policy actors, such as the public-funded cluster organization NCE Maritime CleanTech, have been especially astute in lobbying regional and national actors involved in maritime administration and rulemaking to implement new green standards and solutions. Within salmon aquaculture, national developed technology standards are a prerequisite for the new development licenses, and these licenses represent a demand side action for the growth of a market for new green technology. Regarding CCS, national policy has supported verification and implementation of this new technology, and stricter CO₂ tariffs in the future should also influence the market for CCS.

Third, resource reconfiguration is essential for green restructuring. To drive change, existing resources or assets need to be nurtured, modified, and redirected. In our case, we have observed how public-funded cluster organizations have collaborated to stimulate crossover innovations (GCE Ocean Technology, NCE Seafood, and NCE Maritime CleanTech). Actors within the maritime sectors have reused existing resources and capabilities in developing the new green battery technology trajectory, and technology developed within the oil and gas sector has been reused and adapted to promote sustainable salmon aquaculture solutions. The development of CCS is still in its initial phase, and the potential for reusing and modifying existing resources and capabilities from the petroleum sector has not yet been realized, but informants argue that the full-scale project is important for further upscaling the technology.

Finally, there is the need for policy mix coordination. A mix of initiatives, both national and regional, are needed to promote regions' green industry restructuring, and in our case, we have focused on the need for coordinating different policy levels. The development of battery technology in the maritime sector illustrates how different policy initiatives work in tandem and how a regional policy actor (NCE Maritime CleanTech) ensures coordination of different initiatives. On the contrary, our salmon aquaculture greening case is one instance of a strongly linked nationally initiated policy (development licenses), which restricts the potential for a more coherent and extensive regional salmon aquaculture greening. The test center for CCS is another example of a national initiative, showing that future success depends on couplings with regional policy initiatives that mobilize other resources, such as the regional capabilities of industry actors.

Overall, we have observed different technology transition pathways within our case region and different levels of greening. Within the maritime sector, the development of battery technology has successfully been accompanied by new market creation, and it represents an ongoing deep green restructuring of the region's maritime industry. In relation to the seafood sector, whether the development of technology for sustainable salmon farming will become economically viable in the long term remains uncertain. Several other environmental concerns also remain for the industry. We classify this new technology pathway as a light green technology transition. Finally, the development of CCS in the petroleum sector is a contested case. While it will certainly reduce the carbon footprint of the sector, it may also contribute to extending the region's dependence on oil and gas.

Our case of green restructuring in Western Norway also provides an illustration of the change agency of various policy actors operating at different levels of governance. Regional policy authorities (the county council organization) have performed institutional entrepreneurship by changing the rules of the game through introducing new requirements for ferry contracts, while the cluster organization (NCE Maritime CleanTech) has performed place-based leadership by coordinating and mobilizing

regional actors within the maritime sector and by lobbying for green specification within national regulation schemes. The introduction of development licenses promoting sustainable technologies within salmon farming has changed the rule of the game for industry actors and represents institutional entrepreneurship by national policy actors. In addition, there has also been important agency performed by regional support actors, that is, the seafood cluster organization, to ensure regional resource reconfiguration. Moreover, the groundbreaking opening of a test center for CCS in the region and efforts toward a full-scale solution represents institutional entrepreneurship performed by national policy actors. However, as stated above, the implementation of policy initiatives is not straightforward but a complex process involving multiple actors with different and often conflicting intention and goals (Flanagan and Uyarra, 2016). Tensions are, for instance, linked to public costs of the support for the new green technologies, uncertainties around technologies viability, and how to manage the funding schemes and allocate the support (Fløysand and Jakobsen, 2017; Normann, 2017).

In our theoretical section, we anticipated that regions specialized in traditionally non-green industries will be biased toward minor changes or a light green restructuring. Policy actors are embedded in existing policy regimes and can become risk-averse, which can downplay their willingness to stimulate radical transformation (Howlett, 2014). However, we have observed change agency and policy action pointing toward a more comprehensive restructuring. It seems like certain time- and space-specific conditions have created an opportunity space for change agency (Roberts and Geels, 2019). Early regional demonstration projects for battery technology turned out to be more successful than expected, and this provided momentum for further growth and action by regional policy actors. Regarding the development licenses in salmon farming, widespread concern among customers triggered policy action from national authorities. Norway has for a long time been a pioneer within CCS technology, but the Paris agreement triggered a renewed interest in CCS as a climate mitigator, also in our case region.

Conclusion

In this article, we have addressed the role of policy for green restructuring of specialized industrial regions. Herein, we have argued for a stronger focus on directionality in policy formulation, both at the regional and the national levels. This implies broadening the goals and objectives of innovation policy and acknowledging multiple roles of the state in transformative change. In our case, directionality is about prioritizing green objectives, which requires effort to align multiple visions and particularly to reconcile growth and employment objectives with visions of more sustainable futures. This requires inclusivity when defining the desirable direction and an appreciation of both the production structure and the region's environmental challenges. This is particularly important and challenging in specialized industrial regions, such as our case region Western Norway, to overcome resistance and secure legitimacy for a vision for green restructuring.

Acknowledging that limiting interventions to extending and improving regional resources is likely to lead to lock-in at worst and to incremental changes at best, we have proposed a more comprehensive approach to policy action for the greening of regional industries. We argue that restructuring requires a broader framing than prescribed by conventional innovation policy approaches in terms of policy action domains, instruments, and goals. We propose a framework consisting of four dimensions that seek to combine the place-based view of studies of restructuring within EEG with socio-technical transition studies focus on transformation to allow for a confrontation of analytical concepts with the particularities of regions.

Our framework of four policy dimensions represents a novel scheme for assessing the role of policy in green restructuring. Through our case study, we have further nuanced this scheme and added to the theoretical debate. First, we have observed that such framework needs to be place and time sensitive. Within our case region, there are several new green technology pathways escalating, representing different level of greening and various mixes of policy initiatives. Second, we have also observed that there will be different types of agency by policy actors

operating at various levels of governance promoting these greening processes. Policy actor's ability to facilitate policy experimentation, nurture new green markets, stimulate resource reconfiguration, and effectively coordinate a broader panoply of policy levers are critical factors for promoting green restructuring. However, we also need to be aware of the temporal conditions making such policy action for a more sustainable future possible. Third, we also acknowledge the complexity of directionality and policy implementation. We argue for the need to depart from observations such as those in this article, that is, how to develop theory-informed requirements for policies for green regional industrial restructuring, to also conduct in-depth studies of implementation processes and the geographical particularities of green policy implementation (or to frame it differently, studies of how and by whom "directionality" is shaped). Hitherto, this "opportunity space" for policy action has been insufficiently addressed, and, based on the work in this article, we argue for the importance of further theoretical and empirical work on implementation of green policies in regions, not only their requirements for the greenness of the policies themselves. We need, for instance, to know more about tensions and dilemmas for policy implementation, the role of policy for green restructuring in other types of regions, and how green restructuring dilemmas play out in different types of regions.

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Notes

1. Herein, green industries are understood as those that "develop and sell products, solutions or technologies that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services" (United Nations Environment Programme, 2011: 16, cited in Grillitsch and Hansen, 2019: 2166).
2. Since 1 January 2020, Hordaland county has been part of the new Vestland county.
3. See <https://www.bt.no/nyheter/innenriks/i/2d1Kmr/oeygarden-ordfoerer-det-stoerste-siden-sotrabruable-bygget>.

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