A Economy and Space

Socio-spatial dimensions in energy transitions: Applying the TPSN framework to case studies in Germany

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Abstract

Energy transitions cannot be fully grasped without appreciating their spatial implications. This paper takes up the idea of conceptualizing the socio-spatial dimensions of energy transitions and examines the respective value of the Territory, Place, Scale, and Network (TPSN) framework. The fundamental contribution of this framework is to move the focus of the debate away from whether one ontology of the socio-spatial is 'better' than another. By applying the TPSN framework to emblematic cases of regional energy spaces in Germany, we realized that the dynamics of different fields of action within an energy transition are characterized in each case by a specific pattern of the four socio-spatial dimensions and related strategies. The paper concludes with a discussion of the benefits and the shortcomings of the framework as it relates to understanding energy transitions. The fundamental role of place-making at a nexus with territorializations, as well as the additional importance of networking and rescaling strategies, are to be understood with the additional factors of the role of governance spaces, the upscaling of local experiments, powerful space-related discourses, and the socio-materiality of spaces.

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Introduction

Research on energy and energy transitions has been criticized for a long time for not being spatially sensitive. Yet, for some years now, there has been a 'spatial turn' in energy research (Bridge, 2018: 12). This research considers that the relationships between energy and society take different forms across space, as energy infrastructures have their own specific socio-materialities and territorializations, and energy policies are pursued in different local, regional, national, and supranational settings. Moreover, energy transitions reconfigure spatial patterns of social, cultural, and economic developments and everyday practices; have material consequences for landscapes and infrastructures; and result in uneven and contested spatial developments (Bouzarovski et al., 2017; Gailing and Moss, 2016; Huber, 2015; Labussière et al., 2018).

Spatial research on energy has become a rapidly growing field of scholarship (Calvert, 2016; Castán Broto and Baker, 2018), with numerous empirical studies researching the overarching role of spaces, as well as outlining fundamental categories of the specific spatiality of energy transitions. Bridge et al. (2013) provided six categories to describe and assess the geographical implications of a transition towards low-carbon energy: location, landscape, territoriality, spatial differentiation, scaling, and spatial embeddedness. Another conceptual framework (Bridge et al., 2018) for unpacking the spatial elements of energy transitions adopted the concept of 'energy landscapes' in order to highlight the material practices associated with energy consumption and production. It distinguishes between resource landscapes, economic landscapes, infrastructural landscapes, and geopolitical landscapes. Becker et al. (2016: 107) identify three emblematic themes: the production of space and uneven development in energy transitions, the rescaling of energy governance, and the spatial materiality of energy transitions.

In all of these cases, the authors have combined their categorizations not only with specific empirical examples related to the energy sector, but also with conceptual perspectives on energy transitions. Nevertheless, one interesting research void of these important contributions is the question of whether our general concepts of spatiality, which are not originally rooted in the empirical context of energy research, have to change when we engage with the energy sector. In order to meet this overarching goal, we decided to select one of the most seminal and comprehensive ways of conceiving the spatiality of social relations: the Territory, Place, Scale, and Network (TPSN) framework developed by Jessop et al. (2008). This multidimensional framework has not yet been applied extensively in socio-spatial research related to energy, with only a few exceptions. Chandrashekeran (2016) used the example of the energy transition in Australia to show that territory, place, scale, and network interact to enable or to inhibit sustainable change and are important for understanding regime change. The TPSN framework has also been applied to spatial strategies of key actors in the development of district heating and combined heat and power systems as material systems shaped by dynamic power relations in Sweden (Nciri and Miller, 2017). Additionally, Dietz et al. (2015) have discussed the political ecology of the socio-spatial dynamics of agrofuels and the related spatialized North–South relations by using at least three of the categories of the TPSN framework. In these cases, the TPSN framework has proved to be a fruitful entry point for understanding the spatialities of energy transitions.

From our perspective, the value-added of the TPSN framework compared with existing analytical approaches in the field of energy geography is the fact that it abstracts from a certain empirical field of research. It allows us to discover the role of a few categories of spatiality in the field of energy transitions and their interrelations. Nevertheless, we consulted the valuable existing perspectives in the field of energy geography when substantiating the four categories of the TPSN framework for our analytical approach.

This paper seeks to take up the idea of conceptualizing the socio-spatial dimensions of change in the energy sector. We therefore re-examine the value of the TPSN framework for researching energy transitions by applying it and by assessing its advantages and shortcomings in the field of renewable energy regions. The application of the TPSN framework to renewable energy regions provides insights into: (a) the dynamic interrelationships between territory, place, scale, and network; (b) the particularities of specific spatial actor strategies in the face of issues of regional energy transitions; and (c) the additional value of further social-science categories beyond the TPSN framework for understanding region-building processes of renewable energies in multiple social constructions. We assume that different fields of action within an energy transition are characterized by specific patterns of socio-spatial dimensions and strategies in each case; therefore, we discuss these patterns of spatial categories with regard to different emblematic cases and the same overarching transition process – the German energy transition.

Methodologically, we analyse the patterns and dynamics of the socio-spatial categories of the TPSN framework via four regional case studies. We selected these cases taking into consideration their importance for the socio-spatial construction and procedural dimensions of the spatiality of the German energy transition. The case studies were conducted using qualitative expert interviews and document analyses. In the end, the analysis of the cases is not about comparing the empirical results *per se*, but about reconstructing socio-spatial interrelationships of territories, places, scales, and networks with their specific patterns and dynamics. The synthesis of the emblematic cases helps to assess the value of the TPSN approach for research related to energy transitions and their spatialities. The German energy transition ('Energiewende') is a fruitful example for analysing socio-spatial dynamics in an energy system because of its fundamental approach of a full nuclear phase-out by 2022 and the rapid acceleration of electricity and heat generation from renewable sources in the last decade. The Energiewende is having a wide-ranging impact on the spatial structures of the energy sector. Important aspects include a trend towards the decentralization of electricity generation and energy governance, new opportunities, discourses and conflicts in local and regional development, as well as new spaces of governance (Moss et al., 2015). The decentralization triggered by the development of renewable energies has led to a growing importance of the regional scale and to new forms of regional energy spaces.

This paper first presents the TPSN framework and its specific features and analytical categories. Second, it shows how this approach can be applied to explore the socio-spatial dimensions and dynamics of energy transitions. Third, it reconstructs and describes the patterns of territory, place, scale and networks in four empirical case studies. Finally, it discusses the advantages and shortcomings of the TPSN framework for future research on energy transitions.

The TPSN framework

The TPSN framework recognizes the polymorphic nature of socio-spatial relations (Miller and Ponto, 2016). Bob Jessop, Neil Brenner and Martin Jones developed this approach in order to avoid what they call 'one-dimensionalism' (Jessop et al., 2008: 391). From their

point of view, researchers often fall into the trap of conflating a part (territory, place, scale, or network) with the totality of socio-spatial organization. This happens, for example, when all aspects of socio-spatial relations are subsumed under the rubric of a state-centric, narrow understanding of territoriality. Thus, Jessop et al. move the focus from a single dimensionality to a multidimensionality of spatial ontologies (Beveridge et al., 2017). They proposed that the polymorphy of socio-spatial relations should be explored by researching territory, place, scale, and network in combinations, so that there is a focus on the interdependencies between these dimensions.

The task of researching the establishment of new energy spaces on the regional scale entails not only taking a closer look at the specific socio-spatial dimensions themselves (e.g. the role of territories for the constitution of a bioenergy region), but rather focusing on the interrelations between them (e.g. the role of places for territorialization processes and their embeddedness in scalar relations). The specific combination of socio-spatial dimensions is not a pre-given result of a well-organized process, but is full of contradictions and conflicts (Jessop et al., 2008: 394). Interestingly, Jessop et al. do not define the four dimensions in a strict and narrow way, in order to allow for exploratory studies and to avoid one-dimensionalism. They leave place, territory, scale, and network open (Paasi, 2008a: 408). This opened up the framework to criticisms that it underplays certain categories, like the role of actors and interests (Mayer, 2008) and excludes other key spatial categories like 'region' (Paasi and Metzger, 2017). The legitimization of the choice and number of privileged dimensions, the equivalence of these dimensions, and the priority of one of these have been discussed by Casey (2008). He points out that place is more formative and generative, and that territory, scale, and network draw their primal sense from place.

There have been further critiques that the TPSN framework represents a rather structuralist approach because it imposes its four categories of spatiality, rather than facilitating an exploration of individual accounts of socio-spatiality (Tan, 2016). At the same time, with its roots in critical realism and regulation theory, the TPSN framework represents a perspective that focuses more on structural or material aspects of contentious politics in capitalist states; this leaves room for combining the TPSN framework with poststructuralist perspectives and/or criticizing it from those perspectives (Miller, 2013). The TPSN framework makes contingent relations of socio-spatial categories a subject of research, opening up opportunities for relational thinking in human geography, but at the same time does not represent a flat ontology that undermines prior conceptual categories (Marston et al., 2005).

Although the authors of the TPSN framework dispense with strict definitions, they present some analytical foci that are associated with these dimensions (Jessop et al., 2008: 393). One form of organizing space, 'territory', relates to the construction of inside–outside divides by means of bordering, bounding, or parcelization. Further important aspects of territoriality are the control of space (Paasi, 2008b: 109) and, thus, the way social and political power is organized and exercised over space (Bridge et al., 2013: 336). When it comes to energy, several issues are territorialized: historically, the integrated national grid systems within the borders of nation states; nowadays, initiatives seek to strategically territorialize low-carbon transitions at the urban or regional scale. This acknowledges that territories are not given, but are areas of strategy and power (Bridge, 2018: 17) constructed through institutions and agency.

'Place', as the second dimension, is conceived in terms of proximity, spatial embedding and areal differentiation, and resulting identities. Each place is perceived as particular and singular (Agnew, 2011). At the same time, places are the location of social practice and meaning that can be consumed and produced (Miller and Ponto, 2016). Energy places

include, for example, the locations of mines, wind farms, or grids and the identities and practices attached to these elements and structures.

'Scale' refers to the hierarchization and vertical differentiation of social relations or the construction of scalar divisions as socio-spatial structuration (Jessop et al., 2008: 393). Scales are never fixed, but are constantly restructured in terms of their extent, content, relative importance, and interrelations (Swyngedouw, 2010: 9). In energy geography, it is acknowledged that the multiple scales of an energy system do not exist *per se*, but as a result of a politics of scale and connected rescaling strategies in the energy system (Becker and Naumann, 2017; Bridge, 2018).

'Network', as the last dimension of the framework, is characterized by interconnectivity and interdependence. Networks are understood in terms of nodal connectivity and the differentiation of social relations among nodal points within topological networks (Jessop et al., 2008: 393). This category reminds us of the relationality of spaces (Paasi and Zimmerbauer, 2016: 90). Energy spaces are characterized by infrastructural networks to distribute electricity, oil, gas, or heat, in the face of the spatial division of production and consumption. At the same time, however, they are influenced by the actor networks and related interactions (Newell et al., 2017: 207). Both types of networks influence spatial dimensions of an energy transition.

In order to research the interdependencies between the four dimensions of the framework, Jessop et al. differentiate between the role of the dimensions either as a structuring principle or as a field of operation. Thus, a territory, as a structuring principle or a causal mechanism, can impact the other three dimensions or it can be produced through their impact. This results in the methodological approach of a matrix with 16 cells. 'This figure should not be seen as the product of taxonomic folly or as a formalistic exercise in populating cells – it has a definite heuristic purpose' (Jessop et al., 2008: 396). Table 1 shows the polymorphy of socio-spatial relations by combining the four dimensions – territory, place, scale, and network – as structuring principles with the respective fields of operation. We named these processes by combining a structuring principle and the respective field of operation (e.g. 'place-based territorialization').

Table 1 helps us recognize that the spatial categories, as structuring principles, are linked by strategies leading to the establishment of new socio-spatial organizations in different fields of operation. Thus, it is not only about territory, place, scale, and network, but about territorialization, place-making, scaling, and networking as 'historically and geographically

Table 1. Socio-spatial strategies in two-dimensional relationships between territory, place, scale and network.

Socio-spatial strategies		Fields of operation			
		Territory	Place	Scale	Network
Structuring principles	Territory	Territory-based territorialization	Territory-based place-making	Territory-based scaling	Territory-based networking
	Place	Place-based territorialization	Place-based place-making	Place-based scaling	Place-based networking
	Scale	Rescaled territorialization	Rescaled place-making	Rescaled scaling	Rescaled networking
	Network	Network-based territorialization	Network-based place-making	Network-based scaling	Network-based networking

Source: based on Jessop et al. (2008: 393) and Jessop (2016: 24).

specific, strategically selective modes … that underpin the concrete-complex geographical landscapes within which particular TPSN combinations emerge' (Jessop et al., 2008: 396). Territories, places, scales, and networks are always embedded in social relations and agency; they are not fixed categories, but modes of action or strategies of individual and collective actors that are engaged in contentious politics. This shifts the perspective of research from the individual categories and their two-way causal interrelationships, to the dynamics and complex procedural chains of TPSN combinations.

Researching socio-spatial dimensions of the energy transition in Germany

Germany's ongoing energy transition cannot be fully grasped without appreciating its spatial impacts and implications. The rapid switch to utilizing renewable energy is reconfiguring the spatial structures and relations of energy provisions in Germany. This applies not only to the physical location of new infrastructures for wind, solar, and bioenergy, and the spatial reordering of energy and resource flows as a result, but also to major shifts in the socio-spatial organization and governance structures of electricity generation and use. In order to better understand these socio-spatial dimensions of the German energy transition, we have applied the TPSN framework. Accordingly, the reconfiguration of an energy system is characterized by a multitude of socio-spatial dimensions, their causal interrelationships, and further linkages of TPSN combinations.

We applied these aspects of the TPSN framework to explore the socio-spatial dimensions and dynamics of the energy transition in Germany with four case studies. Each subsection follows the same structure. First, we introduce the type of case study, outlining its specific role in the German energy transition. Subsequently, we present the case study area and the particularities of each case. In order to show that the complex interrelationships of TPSN play an important and particular role, we describe the specific patterns of the four socio-spatial dimensions and strategies in each case. The designation of each case study as a combination of a structuring principle and the respective field of operation is a core aspect of each of these patterns. Each case study section concludes with a discussion of the additional value of further social-science categories beyond the TPSN framework in order to better understand the multiple socio-spatial dynamics involved. This helps to widen the perspective of the TPSN framework and addresses some of the critiques mentioned above.

The four case studies were selected because of their theoretical importance as emblematic cases. They focus on typical processes related to the spatiality of the German energy transition. The first case is about the creation of a new 'energy region', which is a typical way of facilitating collective action at the regional scale in order to increase acceptance and economic participation (Gailing and Röhring, 2016). These activities at the regional scale are indicative of a complex rescaling of energy politics. The second case is about new opportunities made possible by the German energy transition and the related spaces of experimentation. The liberalization of energy production has created opportunities for regionally and locally based initiatives to generate electricity from renewable sources. This has fostered urban energy projects to find and disseminate innovative solutions.

While the first two cases are characterized by proactive and – at first sight – consensual activities to foster the energy transition as a positive aspect of regional development, the last two cases are examples of the conflicts and contradictions that can arise related to energy transitions. The third case thematizes the arenas of dispute concerning the development of

new wind farms. The availability of space is elevating the importance of rural areas, which are not only delivering the principal achievements of the Energiewende, but also bearing the brunt of the landscape interventions and a growing number of energy conflicts (Reusswig et al., 2016). The last case study is about a region with both a traditional, fossil-fuel-based generation of electricity and renewable energy projects, with their respective actor constellations and institutional settings. This is typical for the German energy transition, with its still predominant role of lignite-based electricity.

Case study findings

Bioenergy region Bayreuth as a space of governance: Network-based place-making

The establishment of 'energy regions' has been a response to the incentive-driven development of renewable energies since 2000. The Renewable Energy Sources Act (EEG), with its guaranteed feed-in tariffs, proved to be effective in fostering renewable energies, though it also had negative effects, such as contributing to landscape changes in rural areas and a lack of participation. In order to improve acceptance at the regional scale, governance structures, in the form of 'bioenergy regions', were supported as pilot projects by the German Federal Ministry of Agriculture from 2009 to 2015 (Bundesministerium für Ernährung und Landwirtschaft, 2015). The bioenergy region of Bayreuth is situated in the north of Bavaria, in a low mountain region around the medium-sized town of Bayreuth. In 2008, the 'Region Bayreuth' was established as a regional management agency by the city of Bayreuth and the neighbouring rural district of Bayreuth. To take part in the 'bioenergy region' competition, the development of a concept to address place-specific problems connected to bioenergy, the definition of goals to increase the installed capacity of biogas plants, and the establishment of governance structures were required.

   The territorialization of the bioenergy region was based on the existing 'Region Bayreuth', extended by municipalities of the neighbouring district (Rothammel, 2014: 13). The structuring principles of the territorialization of the bioenergy region of Bayreuth can be interpreted as essentially territory-based (a region constituted by formal territories of districts) in combination with a network-based inter-municipal association. The combination of socio-spatial relations included existing regional collaboration experiences and governance structures that were able to support the management of the bioenergy region.

   Networking aimed to motivate and encourage the collaboration of regional actors and the acquisition of financial resources to realize bioenergy projects. The actor networks incorporated stakeholders from civil society, the regional economy, agriculture, government authorities, and also art and culture stakeholders. The networking activities maintained the territory of the bioenergy region by intertwining relational and territorial dimensions (Paasi and Zimmerbauer, 2016: 90). Networking is a necessary precondition for place-making in bioenergy regions. Place-making, as a core activity of bioenergy regions, aims to explore the innovative ways to improve regional participation and reduce potential conflicts in the Bayreuth bioenergy region (Regionalmanagement Stadt und Landkreis Bayreuth, 2012: 3). To reflect landscape changes due to renewable energy and to promote the identity of being a bioenergy region, landscape art projects were initiated, crosslinking the bioenergy projects within the region and strengthening the concept of singularity of place. Three large-scale sculptures corresponding to the renewable energy sources in the region (sunlight, wood, and crops) were established as landmarks. These projects have been closely linked with environmental education and integrated into tourist marketing. Other activities focused on analysing the tensions between energy, food, and nature. In these ways, place-making

aims to improve not only material structures but also to develop awareness of renewable energy.

The different roles of territories, places, scales, and networks in the Bayreuth bioenergy region reflect the constellation of region-building and the tension between the requirements of governmental support and regional actor constellations. Although place-making activities were the goal of bioenergy regions, their territorialization was a precondition for participating in the 'bioenergy region' competition. Their spatial definition was based on existing territories but also on actor networks, as structuring principles, and less related to joint problems of place. The realization of projects required networking between actors. Due to this, networking was a precondition for a diversity of place-making activities aimed at improving socio-material structures and developing renewable energy awareness and the region's identity as a renewable energy region. Based on this, bioenergy regions are examples of network-based place-making. In the district of Bayreuth, this strategy proved to be successful, with the installed capacity of biogas plants increasing 66% between 2009 and 2015 (Deutsches Biomasseforschungszentrum, 2019).

This case study shows that the relationship between networking and place-making based on territorialization is crucial for understanding regional spaces of governance. At the same time, it has made it clear that in order to understand 'energy regions', the perspective of the TPSN framework should be complemented by the agency-oriented approach of spatial governance (Jessop, 2018: 93–94). From an extended spatio-temporal perspective, the Bayreuth bioenergy region, supported by the federal government as a pilot project for six years, is only a sequence of consecutive spatial governance structures implemented mainly by the rural district of Bayreuth, based on diverse governmental support programmes. In 1996, an agency for rural development was established. In 2007 the 'Klimaregio Bayreuth' was formed by the 'Region Bayreuth' (Regionalmanagement Stadt und Landkreis Bayreuth, 2008: 7–8). One of their projects focused on their participation in the 'bioenergy region' competition. In 2015, as the financial support of the management of the bioenergy region expired, a climate protection management team was established in the rural district of Bayreuth. Until 2018, it supported the implementation of projects related to the integrated climate protection concept and to pursuing positive outcomes of the bioenergy region. Further structures of regional governance, like tourism regions, cooperated with the bioenergy region. From this extended spatio-temporal perspective of sequential and coexisting spaces of regional governance, the polymorphic relationships between territory, place, scales, and networks hold more complexity. In addition, it highlights the tension between the temporal limitations of governmental support and the requirements needed for stable but adaptive structures of regional governance.

Upscaling of local experiments in Baden-Württemberg: Place-based scaling

The success of the Energiewende depends on the dynamics in the multi-level German system. This case study focuses on these dynamics in the south-western German federal state of Baden-Württemberg. It concentrates on the relationship between place-making and scaling in the context of the upscaling of local experiments, and the related development of experimental spaces. Leading cities such as Freiburg and Heidelberg pursued place-making and scaling strategies to build up their reputations as green cities.

Historically, energy policy in Baden-Württemberg was shaped by nuclear energy and a strong cooperation between the state and the dominant utility company (Bontrup and Marquardt, 2010; Scheiner, 2017). Starting in the early 1990s, pioneering cities in the region became active, developing far-reaching initiatives related to climate protection and

setting emission-reduction goals that were far more ambitious than the goals of the federal state. Since cities such as Freiburg and Heidelberg started place-based action at a very early stage, they developed into exemplary leaders in climate protection in Germany. This was supported by their engagement in city networks in the field of climate and energy policy (Graf et al., 2018; Kern and Bulkeley, 2009).

Since the percentage of energy stemming from nuclear energy in the state was high and CO_2 emissions per capita low, at least compared to other German states, Baden-Württemberg's climate reduction goals were modest at best. Initiatives concentrated on energy saving and were aimed particularly at households, as well as small and medium-sized companies. However, it became evident that the state would not even reach its modest reduction goals. While the federal state government supported the expansion of bioenergy and solar energy, it strongly opposed wind energy. This led to scalar conflicts between the city of Freiburg and the Baden-Württemberg state government, which rejected Freiburg's plans to build wind turbines in the Black Forest (Galvin, 2008; Späth and Rohracher, 2011). However, the federal state government set up a new subsidy programme called Climate Protection Plus (Klimaschutz-Plus) in 2008, which included subsidies for municipalities and districts from the outset, in particular providing financial resources for pilot model projects and energy agencies at the district level. This ended up in a rescaling of the energy policy, with new competences and actors at the district level, and thus with new kinds of social relations (Jessop et al., 2008: 393), preserving the federal state as an important scale, but establishing a new state-dependent but better-equipped district scale of energy governance.

In 2011, shortly after the Fukushima disaster, a green–red coalition government came into power in Baden-Württemberg. This government enacted a climate protection law, set binding CO_2 emission-reduction goals (at least a 25% reduction by 2020 as compared to 1990), and pushed for the expansion of wind energy. Klimaschutz-Plus was expanded, and subsidies for municipalities and districts were linked to other programmes that support place-making and foster networking opportunities related to climate protection, such as the European Energy Award and the federal government's subsidy programme for municipalities. These initiatives enabled many cities, towns, and districts to establish climate protection strategies, hire climate protection managers, set up regional energy agencies, and fund pilot projects. These initiatives led to a 12% reduction of CO_2 emissions by 2016 at the federal state level. The city of Freiburg, for example, had already reduced its CO_2 emissions by 30% per capita by 2014.

Upscaling of local experiments is facilitated if an experiment was developed and successfully tested by a leading city. This means that the place where a local experiment occurs is crucial for upscaling it. Place-making in the area of climate protection, which is based on physical structures, identities, and shared values, has an internal and an external dimension. Internally, pioneering cities such as Freiburg and Heidelberg had already started to set up climate protection strategies in the early 1990s and built up their reputations as green cities in a strategic way. Pilot model projects, such as the urban quarter of Vauban in Freiburg, have influenced city planning and even improved Freiburg's visibility outside city borders. Externally, Freiburg and Heidelberg stabilized and consolidated their reputations as leading cities in climate governance – for example, by collecting national and international awards. By setting up and joining transnational networks, they created new spaces of experimentation. Local experiments depend on networks that include relevant stakeholders. Network-based place-making is most relevant for place-making at the local level, while place-based networking is crucial when cities establish regional, national, and international networks to learn from each other.

Upscaling of local experiments is a process that can be characterized first by the expansion of place-based experiments. This means that upscaling is limited to the city in which the experiment started; for example, the roll-out of a pilot project from one neighbourhood to others within the same city, driven by project-to-project learning. Second, diffusion of local experiments on a voluntary basis leads to horizontal upscaling between and among cities, based on various forms of spatial networking, ranging from city twinning to transnational networks. This facilitates the transfer of good practice, developed by leading cities, to cities that have not yet started their own initiatives but have the capacities needed to follow the leaders. Third, the transformation of all cities in a specific territory requires additional forms of upscaling, which involves the state. Vertical upscaling, such as new funding programmes (e.g. for hiring a climate manager or setting up a regional energy agency) and programmes that stimulate new forms of networking (e.g. networks between climate managers or agencies) are essential for engaging municipalities and districts that lack the necessary capacities.

This case study shows that the perspective of upscaling and the role of spaces of experimentation are important additional perspectives to be added to the TPSN framework. At the same time, the TPSN dimensions and their dynamics are important ways of interpreting processes of upscaling. At the neighbourhood level, new solutions to existing problems can be tested within a limited territory and with limited consequences. Successful experiments can be rolled out to the city level, which broadens and expands the space of experimentation beyond laboratories at the neighbourhood level. City networking opens up new spaces of experimentation, in particular if networking is supported by the state, such as by setting up platforms for leading cities.

Discursive spaces of contentious wind energy in Brandenburg: Place-based territorialization

With this next case study, we explore how actors use socio-spatial dimensions like territory and place in a strategic way, while focusing on conflicts over wind turbines in the German north-eastern federal state of Brandenburg. This case study provides an example of how the TPSN framework can be applied in a dynamic and discursive way to describe and understand the emergence of a highly conflictual discursive space; it follows the idea of Jessop et al. (2008: 397) that the TPSN schema can fruitfully inform the field of contentious politics.

Germany's north-eastern federal state of Brandenburg had onshore wind-power installations with a capacity of 6794 MW at the end of 2017; in this regard Brandenburg occupied third place among the 16 German federal states (Deutsche WindGuard, 2018). On three consecutive occasions between 2008 and 2012, Brandenburg was awarded the bi-annual lodestar award ('Leitstern') for the German federal state that achieved the best results in expanding the rate of renewable energies produced each year. This success story was based on energy transition goals that had been set by the state government in energy strategy plans developed in 2008 and 2012, which stated that by 2030 40% of the final energy consumption in the federal state should be covered by renewables.

Brandenburg has gradually increased its wind energy capacity since the mid-1990s, but protests against wind turbines became more forceful and visible around 2010 and had already resulted in a gradual decrease in Brandenburg's share of installed capacity of wind energy in Germany (Wirtschaftsförderung Brandenburg, 2018). The umbrella organization Rettet Brandenburg (Save Brandenburg) unites approximately 100 local protest groups. In 2015, Rettet Brandenburg engaged in a public initiative (the first mandatory step towards a public referendum) that requires 20,000 signatures to urge the federal state parliament to address their demands. These demands included the call for a setback of

10 times the height of a turbine to the next residential area and a ban on the construction of wind turbines in forests. Rettet Brandenburg successfully submitted 33,000 signatures to the Brandenburg state parliament. This was followed by a hearing, but their demands were dismissed. The organization consequently embarked on the second step of a public referendum, but failed to mobilize the acquired 80,000 signatures. This conflict over wind turbines has unfolded in a discursive space that can best be understood by the TPSN categories of territorialization and place-making, but also includes aspects of networking.

Territorialization is a socio-spatial strategy that refers to the construction of inside–outside divides. Creating spatial boundaries that delimit one type of land use from another best describes Brandenburg's approach to spatial wind energy planning. While the financial conditions and incentives of wind turbine development in Brandenburg are determined via the EEG, Brandenburg has considerable leverage in steering wind energy via regional planning. Five planning regions designate the areas suitable for wind energy, outside of which the construction of wind turbines is forbidden. Several directives from the Brandenburg government have specified the terms by which the planning regions should develop their plans, which will determine the sites where wind turbines are admissible and where not. Territorialization is thus a key strategy of the Brandenburg government and has been one of the reasons why the federal state has become a German frontrunner in wind energy production.

Opposition to wind energy in Brandenburg has largely been informed by place-protective argumentation. The concept of place-protection postulates that opposition to wind energy projects can be understood as behaviour taken to protect one's place. Following this notion, local opposition 'arises when new developments disrupt pre-existing emotional attachments and threaten place-related identity processes' (Devine-Wright, 2009: 426). Place-protection involves material place-making practices such as putting up protest signs and banners, but it can also be employed in a discursive way. During the campaign for the public referendum, protest groups in Brandenburg put up protest signs to prompt residents to sign up for the campaign. Additionally, place-protection is also visible in both the formal demands the movement put forward (larger setbacks and no wind turbines in forests), and also became apparent in interviews with members of local protest groups. Many of them spoke of the 'industrial invasion' of wind turbines into their 'pristine land', thereby making a case for place-protection. This argumentation was a central component of efforts to garner support – that is, to engage in networking strategies. The wind opponents' strategy of place-making, to oppose the further construction of wind turbines, is a direct consequence of the territorialization strategy of regional planning. A networking strategy of anti-wind opponents aims to mobilize more support from the public.

This case study highlights the dynamic characteristics of a discursive space on wind energy conflicts and adds a discursive perspective to the dynamic understanding of the TPSN framework. It shows that territorialization and place-making are the strategies used by the two main actors involved in the conflict (the regional planning authority and the anti-wind movement). The discursive space of contentious wind energy in Brandenburg is considerably shaped by these discursive strategies and contributes to the dynamic nature of the conflict. A territorialization strategy was at the core of the government's intention to further increase the rate of wind energy produced, and place-making strategies by wind opponents were the direct response to this strategy. Territorialization and place-making are, therefore, directly related and highlight the dynamic and discursive nature of the TPSN framework. At the same time, the case study shows that territorialization can in fact serve as a major implementation strategy for energy transitions. In the same vein, place-making is closely connected to networking strategies of the anti-wind movement, as opponents largely refer to place-related arguments to garner support for their cause.

Old and new energy spatialities in the Rhineland: Rescaled place-making

The last case study is indicative of one of the major problems of the Energiewende: the paradoxical situation that Germany has a leadership role in the growth of renewable energies, while at the same time lignite remains the most important energy source in the country, with accordingly high CO_2 emissions (Morton, 2015; Radloff, 2017). This paradoxical situation results in sites where 'old' and 'new' energy spaces coexist. One region with both a fossil-fuel-based generation of electricity and a growing importance of renewable energy generation is the Rhenisch lignite-mining area in the state of North Rhine-Westphalia in Western Germany. This flat landscape between the cities of Aachen and Cologne is characterized by large open-pit mines and some of the most polluting power stations in Europe. Due to this, the region became one of the main focuses of the climate movement and of protesters against coal-fired energy generation. Furthermore, there are regional governance initiatives seeking a transformation towards producing more energy from renewables and the associated transformation process required for this shift. Thus, this case study is a complex one due to the fact that the energy future of this region is contested. The relationships between territories, places, scales, and network are embedded in the multiplicity of 'old' and 'new' energy spaces and the related actor constellations, contentious politics, and socio-materialities. In the following, we will concentrate on the mining area, the protest space, and the new regional governance arenas.

The relationship between scale and place-making is a crucial one for understanding the spatialities of the Rhenisch lignite-mining area. Local places like the power plants and the mines are embedded in regional images, networks, and discourses that are influenced or even created by national and global objectives and policies. Contrary to wind or solar power, lignite is a resource whose economy and governance is still dominated by big players like the electric utility RWE, as well as by national energy legislation. So, scale plays an important role as a structuring principle for socio-spatial organization, especially for the place-making strategies involved. As for the history of the 'old' energy space, fundamental place categories include the lignite and the resultant open-cast mines as well as the conveyor belts and railway tracks that transport coal to power stations. This kind of place-making, of having transformed a traditional agricultural landscape into a mining and industrial region, was a result of the national energy policy. Lignite was one of the few energy sources available in Western Germany after the Second World War; especially in the aftermath of the oil crisis (but also nowadays), the discourses related to it were connected with ensuring energy supply and economic growth as well as with safeguarding jobs. This scalar creation of a regional energy district resulted not only in the transformation of place, but also in a hard territorialization by regional planning offices in the form of a 'lignite-mining plan' and in strongly tied networks between the energy utility, trade unions, and local politicians. Although the government of the state of North Rhine-Westphalia defined a clear but rather long-term goal to reduce greenhouse gas emissions by 80% by 2050 with its climate protection law of 2013, this did not result in policies to reduce the exploitation of the lignite mines in a substantial way.

Protesters have challenged the mining activities for several decades (Jansen and Schubert, 2014). They created new places of resistance against the enlargement of the mines. Whereas in the beginning these protests focused on the destruction of villages or the lowering of the groundwater table and were, thus, dominated by local groups and environmental organizations, this situation changed with the emergence of the climate movement. Local activities were embedded in the rescaling of the Rhineland as one of the hotspots of resistance against climate change. The occupation of one of the forests severely threatened by the enlargement

of one of the mines and the resulting conflicts were an important success for the people fighting against RWE. The protection of local places thus became a rescaling strategy of a national and even global movement of legal and illegal protests against climate change and growth-oriented economic development (Hambacher Forst Buchprojekt, 2015).

There are different visions for the mining area, some looking for a radical transformation, some looking to carry on. Others are working for a preventive or anticipatory transformation – that is, transforming the energy system towards renewables while the mines and the power stations are being phased out. Governance spaces were created in order to influence the transformation process, like in the case of a development agency around one of the mines. Another initiative – the Innovation Region Rhenisch mining area – was territorialized on the basis of the six districts of the region, at the initiative of the state of North Rhine-Westphalia (Innovationsregion Rheinisches Revier, 2015). Their collaborative approach of place-based networking is not directed against RWE; creating new business opportunities in the renewable sector and socio-technical visions for smart grid development are not preventing the operator of the mines and the power plants from carrying on. Framing the mining area as an 'innovation region' with several pilot projects is a kind of place-making that is supported by a new regional actor constellation, while the old ones continue to operate. This way of transforming the region has recently been supported by the German Commission on Growth, Structural Change and Employment, which initiated a plan to shut down all lignite-fired plants in Germany by 2038.

The rescaled place-making of the Rhenisch lignite-mining area resulted in the integration of local places in global resistance strategies of the climate movement, and in the creation of regional governance spaces for a preventive transformation by government-funded agencies, along with new goals for a national coal phase-out. These rescaling processes, as well as supporting place-based territorializations and networks, are a socio-material integration of the 'new' system into the 'old' one. The specific patterns of this complex constellation of TPSN strategies are very much related to the resources, infrastructures, and physical landscapes involved. The materialities are closely interlinked with specific places and are politicized by regional or national communities. While the 'old' energy space is connected with the spatially fixed mines, power plants, and infrastructures, the 'new' energy spaces of protest or transformative governance are more flexible and can be connected with discourses and practices related to different places and infrastructures. The case of the Rhineland shows that the perspective of socio-materiality is an important one when it comes to understanding the role of polymorphic spatialities in energy transitions.

Overview of the cases

Throughout this section we have shown with our empirical cases that focusing on the dynamic aspects and patterns of territory, place, scale, and network is a crucial task in order to better understand the spatialities of energy transitions. When overviewing the results of the case studies and their discussion, we realized that the dynamics of each of these emblematic cases within the Energiewende is characterized by a specific pattern of the four socio-spatial dimensions and strategies of the TPSN framework. Table 2 gives, on the one hand, an overview of the patterns of two-dimensional relationships between territory, place, scale, and network. These patterns, at the same time, represent the respective socio-spatial strategies of actors and organizations involved. In each of the cases, we were able to differentiate between a dominant pattern and some secondary ones. On the other hand, we have shown that there are other relevant issues in researching the socio-spatiality of energy transitions apart from those brought forward by Jessop et al. (2008).

Table 2. Overview of the patterns of socio-spatial strategies and further aspects of spatiality.

Case study	Dominant socio-spatial strategy	Secondary socio-spatial strategy	Important additional aspects of spatiality
Bioenergy region Bayreuth as a space of governance	Network-based place-making	Territory-based territorialization Place-based networking	Regional governance spaces
Upscaling of local experiments in Baden-Württemberg	Place-based scaling	Network-based place-making Place-based networking	Experimental spaces
Discursive spaces of contentious wind energy in Brandenburg	Place-based territorialization	Place-based networking Territory-based networking	Discursive spaces
'Old' and 'new' energy spatialities in the Rhineland	Rescaled place-making	Place-based territorialization Place-based networking	Socio-materiality of spaces

The additional value of the categories mentioned in Table 2 – the role of governance spaces, the upscaling of experimental spaces, discursive spaces, and the socio-materiality of the TPSN dimensions – will be discussed in the final section of this paper.

Conclusions

The overarching idea of this paper has been to conceptualize the socio-spatial dimensions of energy transitions and, to this end, examine the respective value of the TPSN framework by applying it to emblematic cases of regional energy spaces in Germany. So, what can we learn from the TPSN framework in regards to understanding energy transitions? And what are the limitations of this approach and possible directions for future research?

New energy spaces are characterized by constitutional aspects of territory, place, scale, and network and are, at the same time, influenced by strategies of territorialization, place-making, scaling, and networking. The comparison of the reconstruction of these dynamic patterns of territory, place, scale, and network in our four case studies reveals that place is a fundamental category for understanding energy transitions. The actor strategies of creating a bioenergy region, developing local experiments, planning and contesting sites of future wind farms, and transforming a coal region into an energy region based on renewables are all place-based. Place characteristics are formational for the construction of energy spaces when it comes to, for example, lignite deposits, existing power stations, wind energy conditions, conditions for bioenergy crops, or a sense of place (e.g. as a coal-mining region). Place is not only the most important structuring principle, however, it is also one of the most relevant fields of socio-spatial organization. Place-making is a crucial strategy due to the fact that fostering an energy transition in a specific region is about transforming the location physically and changing the social practices, meanings and identities involved. Labelling a region or a city as a 'bioenergy region', an 'innovation region' or a 'green city', as well as envisioning its future (Späth and Rohracher, 2010), belong to these strategies and are discursively legitimizing renewable energy development. Activists opposing the transition to renewables or the continuation of coal mining use 'place-protection' strategies in order to preserve the existing countryside and the related social constructions of landscapes (Gailing and Leibenath, 2015) by demarcating their places as natural or pristine.

There also seems to be a strong nexus between place and territorialization in energy transitions. Bordering and the construction of inside–outside divides are very much connected with place characteristics and place-making strategies. The construction of new regional action arenas is always a combination of territorialization (e.g. demarcating the borders of a bioenergy region) and place-making (e.g. strategies to improve the social acceptance of renewable energies). Existing territories like municipalities or planning regions play a role as a structuring principle when it comes to formal planning procedures or the foundation of regional governance structures.

The construction of new energy spaces on the basis of existing territories entails new actor networks, and can be considered to be a result of the rescaling of energy policy. Energy transitions are shaped by scalar relationships between national energy laws and their impacts on local and regional communities, related to the development of renewables. In these communities, governance structures and place-making activities have been established to compensate for the problems associated with renewable energy development, and to use renewables as a potential for regional economic development. Scaling and rescaling of other socio-spatial strategies is a crucial dimension of the diffusion of local place-based pilot model projects and experiments in cities. At the same time, there is a strong attempt to rescale political conflicts on the global, European, and national levels, related to the reduction of greenhouse gas emissions in local sites and places, where forests and villages in lignite-mining areas have become 'battlegrounds' of climate policy.

Networking is, in each of our cases, an additional and supporting strategy in order to achieve the objectives of place-making, territorialization, and rescaling. The networking activities of the renewable energy industries, anti-wind protesters, the global climate movement, and traditional energy utilities in order to maintain stable conditions for coal-fired generation are, among others, key examples of socio-spatial interrelationships and their role for energy regions. These networks are directly embedded in socio-material networks of resources, grids, and other infrastructures. Networking does not only mean organizing actors and materialities in networks, but also strategically engaging with relationally networked energy spaces.

So, our general concepts of spatiality do not have to change when we engage with the energy sector. Applying the TPSN framework to socio-spatial questions of energy has been a fruitful endeavour. Focusing the research on four categories and their complex interrelationships is a way of better understanding the transitions going on and the particularities of the empirical field of the energy sector. The TPSN configurations of bioenergy regions, green city experiments, areas designated for wind farms, and lignite-mining areas are sites for, and objects of, socio-spatial strategies (Jessop, 2016: 21), and have their roles in energy transitions.

Working with the framework, however, made us aware of its limitations. For instance, TPSN is about spatial dimensions and strategies of actors, but not about the way power is embedded in spatial dimensions. The role of actor-based and non-actor-based power is important for understanding energy geographies and dynamics in the energy sector; so, there is a clear need to add this category to future case studies in this field. This could entail thinking of the ways TPSN configurations are each powerful – for example as complex socio-spatial dispositives (Pløger, 2008) – and, thus, formative for the subjectivities of stakeholders in the energy sector. Taking the role of power into account may also mean thinking of the politicization and depoliticization of the dimensions of the framework. The Energiewende, as an endeavour of the nation-state, and the myriad local and regional ways of dealing with this political project, show that territories, places, scales, networks, and their combinations can play an important role in defining 'the political' (Huber, 2018) itself.

At the same time, it is necessary to better understand TPSN not only as clear and overtly political strategies, but also as attempts to remove some issues, such as the private, technical, or managerial (Jessop, 2014). Thus, one possible future direction of TPSN research could be differentiating between the obvious and less obvious socio-spatial strategies and re-thinking the powerful role of spatialities when it comes to hiding intentions. One prominent example in our case studies is the 'innovation regions' that may help more to preserve the role of the powerful energy utility than fostering a fossil-fuel phase-out.

Discussing the additional value of 'power' and the 'political' may illustrate that the TPSN framework is not to be understood as a complete answer to everything, but as a useful tool for understanding the socio-spatial dimensions of an empirical field – like the role of energy regions in the German energy transition – and to allow for a synoptic perspective of this field. At the same time, it is important to complement the framework with categories like 'power' and the 'political' and, thus, to widen its perspective. With the case studies in this paper, we identified four additional socio-spatial aspects that we believe are essential in order to conceptualize the spatiality and dynamics of energy transitions. First, from a governance perspective, we can see that energy spaces are not always territories or networks, but sometimes action arenas of collective actors or organizations. Taking, second, the role of upscaling of experimental spaces into account shows that local transitions are embedded in intricate processes of rescaling energy policies. Third, the case study related to contentious wind energy demonstrates the role of discourse and that the socio-spatial dimensions, as well as their configurations, are often discursively produced. Finally, the example of the mining area reminds us that there is a materiality of spaces related to the resources, infrastructure and physical landscapes that is fundamental for understanding place-making and other socio-spatial strategies in energy transitions.

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