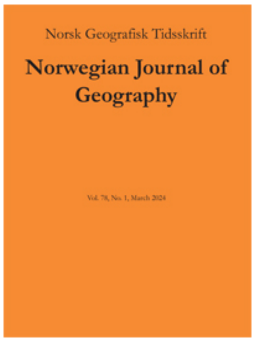

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Analysis of place-based factors in transitions through the lens of a transition space: Insights from Finland's emerging battery industry

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ABSTRACT

Battery production plays a crucial role in Europe's electrification of mobility and production facilities are expected to play an essential role in European value chains in the future. However, this new trend in energy transition raises the question of how individual places and regions can tap into these developments and operationalise multilevel transitions based on their existing capabilities and assets. The purpose of the article is to advance the nascent theorising on the concept of transition space in the geography of transitions literature by studying place-based factors and their various interactions with transition levels. The authors studied the ongoing development of the GigaVaasa battery factory site located in Finland's Vaasa region to explore which factors appeared most relevant in transitions and at which transition levels those factors manifested. The results indicate that place-based factors connect with different transition levels in a transition space, thus enhancing their possibilities for leveraging transition pathways. The authors conclude that strategic planning and the ability to mobilise stakeholders for systemic agency form a critical starting point for successful transition space management.

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Introduction

According to Foglia (2023), the European Union (EU) is increasing its efforts to contribute to the United Nations Sustainable Development Goals and the Agenda 2030 embraced by the European Green Deal and its results-driven agenda. One important avenue for sustainability is transportation, which causes one-quarter of European greenhouse gas (GHG) emissions and is the most important source of pollution in cities (European Commission n.d.). Road transport constitutes the highest proportion of overall transport emissions; it accounted for 76% of the EU's transport-related GHG emissions in 2021) (European Environment Agency 2023). It is therefore evident why European countries in general are keen on making battery-based cars a norm on European soil. Production was long based in China, but recent crises related to the Russian invasion of Ukraine and COVID-19 have pushed forward ideas of European value chains and the need for more local battery production (European Commission 2022). In this agenda, place-based factors have recently become accentuated due to the possibilities of anchoring broad societal transitions to their local surroundings and contexts of policy implementation (e.g. Hansen & Coenen 2015; Murphy 2015; McCann & Soete 2020; Trippl et al. 2020; Coenen et al. 2021; Bianchi et al. 2024). According to Murphy (2015, 83), places serve as 'critical contexts wherein the practices, norms, conventions, and rules associated with sociotechnical regimes are situated'. In short, a place is the context within which regional energy transitions unfold.

The literature on the geography of transitions has emerged to explore and explain the spatial dimensions of transitions, where such transitions occur (e.g. Coenen et al. 2012; 2021; McCauley & Stephens 2012;

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Raven et al. 2012; Bridge et al. 2013; Murphy & Smith 2013; Hansen & Coenen 2015; Mattes et al. 2015; Murphy 2015; Chlebna & Mattes 2020; Strambach & Pflitsch 2020; Joshi & Agrawal 2021) and 'the spatial configurations and dynamics of the networks within which transitions evolve' (Coenen et al. 2012, 968). There has been a call for more contextual, spatially sensitive transition studies to improve the understanding of the place-based factors that support the development of green energy in different contexts (e.g. Coenen et al. 2012; Murphy & Smith 2013). These include raw material deposits, technological potential, formal and informal institutions, cultural variations, economic strategies, policies, and socioeconomic conditions (Hansen & Coenen 2015; Coenen et al. 2021).

This article contributes to the geography of transitions literature by deepening the understanding of place-based factors in transitions. We utilise Geels' well-known multilevel perspective (MLP) framework (Geels 2006; 2019; Geels & Schot 2007) to explore place-based factors in relation to diverse transition levels. The MLP framework explains how sociotechnical transitions happen via interactions on three levels: landscape, regime, and niche. The landscape level represents the top level and comprises market dynamics or legislation. The regime level is a sociotechnical presentation of 'everyday life' or the status quo of the present-today world. The niche level represents individual actors, activities, and innovations aiming to become mainstream by gaining access to the regime level, which is seen to resist new openings or even possess lock-in conditions, which makes changing a regime difficult (Geels 2019).

We advance the nascent theorising of the concept of a transition space that relates to the 'wider network configurations within which territorial transition dynamics are embedded' (Coenen et al. 2012, 969) by studying place-based factors and their various interactions with transition levels. The literature on the geography of transitions has remained relatively silent on the relationality of place-based factors concerning complex transition dynamics. A relational view is needed because the importance of a place-based approach in governing societal transitions is increasingly emphasised in transition studies and effective policy implementation (e.g. Bianchi et al. 2024). For this article, we analysed the interplay between the MLP framework and place-based factors through the lens of transition space, which enabled us to tap into the relational dimensions of place-based factors. Indeed, a place – referring not only to location but also to the meanings and networked practices that constitute them (Cresswell 2009) – is fundamentally a relational concept, comprising a combination of different interacting factors and shaped by forces outside their porous boundaries (Murphy 2015). Thus, energy transitions are not solely reliant on one place-based condition but on their recombinations and spin-off activities (Trippl et al. 2020, 191) intertwined with complex multilevel transition dynamics and endogenous and exogenous factors in transitions (Coenen et al. 2012). The original idea of landscape-level influence and external pressure (Geels 2006) has been accompanied by views underscoring the role of incremental internal change (Martin 2010) and local assets and their roles in transitions (Trippl et al. 2020).

We contribute to the discussion on the geography of transitions by studying place-based factors and their roles in a transition. We advance the literature by answering the following research questions:

1. How do place-based factors interact with transition levels in a transition space? (RQ1)
2. Which place-based factors are relevant to an energy transition in the context of the battery industry? (RQ2)

We studied place-based factors and their relationality through a case study in Finland, namely the GigaVaasa battery industry. GigaVaasa is a battery factory site under development in the Vaasa region within the Ostrobothnia Region of Finland (Bridge & Faigen 2022; GigaVaasa 2022[1]; Löfmarck et al. 2022; VASEK 2023). Analysing the Vaasa region revealed how different place-based factors materialise in the concrete case of a transition space in the emerging battery industry. This allowed us to examine more deeply the practicalities of promoting an energy transition locally.

In our interpretation, the GigaVaasa battery industry represents a niche-level activity that aims to contribute to a transition in a transportation regime towards sustainable mobility (Nykvist & Whitmarsh 2008). We hypothesise that place-based factors' roles in changing incumbent regimes affect successful niche building (i.e. that the relevance and relational presence of place-based factors at broader transition levels improves the possibilities to catalyse the development at the niche level) (cf. Bathelt & Glückler 2005). This hypothesis is supported by, among others, theories of asset management (Trippl et al. 2020) and agency (Sotarauta et al. 2021), which suggest that contextual factors alone are insufficient for explaining spatial differentiation in economic development.

[1]The source of information is a brochure about EnergyVaasa, produced in 2019 with the title 'Establishing a battery factory', and accessed from GigaVaasa (GigaVaasa 2022).

This article proceeds as follows. First, we position our work in relation to the geography of transitions literature and build an analytical framework that consists of three elements: the MLP framework, place-based factors, and a transition space, with the latter contributing to the analysis of the interplay between transition levels and place-based factors. Second, we explain our materials and methods, and provide the background for the case study. Third, we apply the analytical framework to analyse our empirical case of GigaVaasa, which brings forth recent developments in the battery industry in Finland. In the Discussion section, we explore our empirical findings in relation to recent theoretical developments, after which we summarise our key contributions to theory and practice.

Theoretical framework: transition levels, place-based factors, and a transition space

Transition levels

To study what types of place-based factors are relevant in energy transitions, we need to explore transitions and how they occur. We apply the well-known MLP framework to analyse the role of place-based factors in transitions because it has been widely used in transition studies and is suggested to be one of the core frameworks in the sustainability transitions research network (Geels 2019, 187).

A core aspect of the MLP framework is the idea of levels. At the macro-level, coevolution is understood as slow-changing social, cultural, economic, technological, and environmental development that forms a contextual backdrop for dynamics at the micro-level and meso-level (Geels 2006, 1013). According to Geels (2019), coevolution at the meso-level is based on the interrelated activities of social groups, which leads to multiple streams and trajectories that influence each other. The micro-level consists of emerging innovations based on co-construction and mutual shaping between heterogeneous elements. The three levels of co-evolutionary dynamics are integrated into the MLP framework on transitions and rephrased as niche, regime, and landscape (Geels 2006; 2019; Martin 2010). According to Geels (2006, 1013), 'the main point of this perspective was that transitions start in niches, where co-construction dynamics are played out. Further breakthrough and system innovation are the result of interactions between co-evolutionary dynamics at multiple levels.'

To understand transitions, one must understand the role of the regime level because it represents the current situation or existing reality, which is difficult to change. The regime level consists of realities and interlinked activities on all geographical scales (regional, national and international). Geels (2019, 189) describes this interlinkage between existing energy, agrifood, and mobility systems, which are stabilised by the alignments between technologies, policies, user patterns, infrastructures, and cultural discourses that have been created in previous decades. According to Geels (2019, 189), these system elements are reproduced, maintained, and incrementally improved by incumbent actors, such as firms, engineers, users, policymakers and regulators, and special-interest groups. Furthermore, the perceptions and actions of these different social groups are shaped by entrenched shared rules and institutions, which are called sociotechnical regimes. Regimes that resist change can be seen as quite strong, yet they can also help to establish new trajectories. Building on Nelson & Winter's notion of technological regimes (Nelson & Winter 1982), Geels (2006, 1004) initially saw regimes as 'cognitive routines', meaning that people tend to think about things similarly, and this thinking can only change when we learn or experience something new. However, this view has evolved towards a broader perspective on what enables or hinders regime change.

Geels (2019, 189) later synthesised three main lock-in mechanisms, which may explain why innovations in existing systems and regimes are primarily incremental and path dependent. First, there are techno-economic lock-in mechanisms based on vested interests that are against transitional change due to investments (people, equipment and ideas) and economies of scale, which may be substantial with the existing technologies. Second, social and cognitive lock-in mechanisms are routines, shared mindsets, social alignments with existing groups, and user practices and lifestyles. Third, institutional and political lock-in mechanisms, which consist of existing regulations, standards and policy networks, may favour existing practices and production. To change existing regimes, something radical needs to happen: 'Radical innovations tend to emerge in small niches at the periphery of existing systems, through pioneering activities of entrepreneurs, start-ups, activists or other relative outsiders' (Geels 2019, 189).

Geels & Schot (2007) studied ways in which change happens in a multilevel context via different pathways: (1) technological substitution (competing niche innovation replaces a regime after landscape pressure destabilises the regime); (2) regime transformation (incumbent actors reorient in response to gradually increasing landscape pressure); (3) regime reconfiguration (symbiotic niche innovation is incorporated into a regime followed by knock-on effects and innovation cascades that gradually alter system architecture); and

(4) de-alignment and realignment (rapid landscape pressure destabilises a regime, which creates space for multiple emerging niche innovations followed by the regime's realignment around one of them). However, change and novel trajectories can emerge even without external shocks (Geels et al. 2017), which adds to the usability of the MLP framework for studying different types of transitions. This leads us to ask what role place-based factors can play and how they align and interact with these levels.

Place-based factors

According to Sörvik et al. (2019), more contextual studies are needed to improve understanding of the place-based factors that support the development of green energy in different contexts. A place-based approach builds on the premise that geographical context really matters in effective policy implementation and that knowledge in policy interventions should be built in interaction with local actors for geographically sensitive policymaking (Barca et al. 2012).

Coenen et al. (2021, 222) defined place-based factors as 'regional industrial capabilities, institutions, resource endowments, policy portfolios and market configurations'. Other scholars have discussed the following contextual factors: natural resources (e.g. battery materials and clean energy supply), strategic planning (Bridge et al. 2013), industrial and technological potential (Trippl et al. 2020, 189), socioeconomic factors (Bridge et al. 2013), sociocognitive orientation (Coenen et al. 2012), mobilisation and institutional collaboration among relevant actors (Mattes et al. 2015), institutional evolution (Strambach & Pflitsch 2020) and infrastructure (Coenen et al. 2012). Institutional analysis has played a vital role in economic geographers' work on the spatial dynamics of innovation because territorial institutional embeddedness can either catalyse or hamper comprehensive utilisation of place-based resources to enable transitions at diverse scales (e.g. Coenen et al. 2012; Trippl et al. 2020).

Different factors and realities, which influence each other, manifest differently in a place (Murphy 2015; Paniagua 2023). Possibly one of the most critical place-based factors considering our analysis is raw materials, as battery manufacturing is ideally located near these resources due to lower transportation costs and emissions. Pre-existing energy sources influence regional energy transition strategies, economic policies, and investments (Joshi & Agrawal 2021).

However, resource deficiency (selective factor disadvantage), meaning the absence of traditional natural resources (e.g. fossil fuels), may influence the transition trajectory because it motivates regions to develop alternatives based on available local resources (Hansen & Coenen 2015, 99). As a result, a region's economic strategies and policies can be aligned to compensate for such deficiencies. Moreover, adopted economic strategies are often centred on enterprises with high chances of success to maximise economic gains and resource utilisation (Foray et al. 2012). Such strategies can be strengthened by agglomeration economies, such as the adequate supply of skilled labour and active engagement of public and private institutions in green innovation (McCauley & Stephens 2012).

An economic system, institutions, and transition trajectory are shaped and distinguished by their unique historical evolution (Martin 2010), and institutional and cultural variations influence economic activities and outcomes (Hansen & Coenen 2015). Institutions, constituted by 'rules, laws, regulations, norms and values' (Hansen & Coenen 2015, 95), may contribute to the transition process and promote cooperation and knowledge co-creation between various stakeholders, which ensures the continuous availability and exchange of new knowledge through research and information dissemination. In other words, institutions can facilitate 'spatial relationships, networks and relational processes that foster learning and support diffusion' (Murphy 2015, 75).

Furthermore, agentic processes bring a personal dimension to place-based development. They are essential for planning, coordinating and ensuring that contextual factors are utilised optimally to achieve transitions by removing 'technological, economic and institutional barriers' (Trippl et al. 2020, 193). In other words, even though favourable preconditions exist, their potential needs to be harnessed through the active agency of relevant regional actors in order to achieve transitions to a green path (Trippl et al. 2020, 189). Actors work collaboratively to identify place-based needs and competitive advantage areas and to implement regional visions and policies (Foray et al. 2012). Collaboration between such actors occurs at different geographical levels (Raven et al. 2012, 63; Hansen & Coenen 2015).

Moreover, a place often has a mix of heterogeneous actors that exercise their agency in advancing the energy transition (Hansen & Coenen 2015). Organising such actors at regional and local levels is easier because regional policymakers have more knowledge of a place than national actors, which is vital when designing policies to meet local needs (Hansen & Coenen 2015). A regional context hence provides a reasonable basis for place-based governance of transitions in galvanising and fostering collaboration among actors

(Sotarauta et al. 2021, 96) and 'localised interactions and learning to support the emergence of collective expectations and perceptions of future development opportunities' (Grillitsch & Sotarauta 2019, 714). The earlier discoveries cited in this section inspired us to explore how place-based factors could be connected with transition levels to deepen our understanding of transition dynamics.

Transition space

To understand the 'windows of opportunity' for transitions and how place-based factors interact with transition levels, we developed further the concept of a transition space (Coenen et al. 2012) to explicate the relationships between transition levels and place-based factors. The concept of a transition space builds on relational theorising in human and economic geography since the mid-1990s to advance relational thinking (e.g. Boggs & Rantisi 2003) related to complex sociospatial relations between actors and broader societal structures and processes of economic change (Yeung 2005). Relational dimensions of place-based factors can be captured by analysing their interplay with diverse levels and dynamics between micro-theoretical considerations and macro-theoretical considerations (cf. Bathelt & Glückler 2005).

According to Bathelt & Glückler (2005), in contrast to a substantive view of local resources, a relational view of such resources enables overcoming several theoretical shortcomings related to explaining spatial economic development. First, it involves 'the geographical distribution of routines, closely associated with industrial and technological specialisation' (Hansen & Coenen 2015, 95). Second, it entails the 'relations and flows (of capital, knowledge, people) rather than discrete entities such as firms or nation states' (Hansen & Coenen 2015, 94). Third, space is seen as relational and goes beyond the distance between actors that shapes their interactions (Coenen et al. 2012, 969).

Relational theorising in the context of a transition space is fundamentally entangled with territorial transition dynamics that have diverse temporal characteristics and path dependencies. A transition space has earlier been described by Coenen et al. (2012, 969) as a combination of 'wider network configurations within which territorial transition dynamics are embedded, and the institutional environments and arrangements particular to those territories' thus highlighting exogenous and endogenous dimensions within transition. For our analysis in this article, we conceptualise a transition space as a three-dimensional space combining territorial, relational, and temporal transition dynamics. Hence, we frame a transition space as a territorially embedded yet inherently relational networked space in which place-based factors interact with complex transition dynamics at multiple levels and temporal frames (Fig. 1). Our conceptualisation thus moves beyond the territorial-relational divide in geography (Paasi 2012) and draws from geographical literature to advance transition studies in which territories appear as outcomes of 'overlapping and interconnecting sets of social, political and economic relations stretching across space' (Cochrane & Ward 2012, 7).

Drawing from architecture and urban planning studies, Pittaluga (2020) developed the idea of a transition space in a design context that has relevant insights for geographically sensitive transition studies. Setting aside traditional dichotomies – in this case, territorial and relational – transition spaces are characterised by co-presence and intermediateness, connecting to co-evolutionary transition dynamics at and between multiple levels of the MLP framework. Importantly, a transition space connecting territorial and relational dynamics also has a third temporal dimension that consists of both short-term and long-term transition dynamics and processes of path creation. Pittaluga (2020, 3) synthesised the following characteristics of transition spaces through which it is possible to do the following:

> (a) to subvert the rules that usually govern these spaces (social, political, economic), (b) to trigger spontaneous processes of appropriation and management of space, (c) to experiment new ways of use, (d) to maintain and increase diversity and thus to favour communication between different subjects, cultures and ideas, paving the way for hybridisation, and (e) to orient project actions to flexibility.

Recently, the need to study incremental (i.e. internal) change alongside external change has been highlighted in transition studies (Martin 2010). Some external pressure is required to make a change, as landscape-level pressure allows a regime to reorient, thus opening opportunities for radical innovations at the niche level. However, institutional change alone cannot explain every transition facet, especially in the energy field. Trippl et al. (2020) highlight the role of locally embedded assets (e.g. raw materials) in transitions, opening 'windows of opportunity' for a transition space where both external (landscape) activities or local (niche) activities may play a more prominent role. Furthermore, through processes of interlocalisation, 'local actors can exert greater influence on the regime as the scope and degree of their influence consolidate and institutionalises' (Coenen et al. 2012, 975), which hence underscores endogenous factors (either niche-based or regime-based) in transitions.

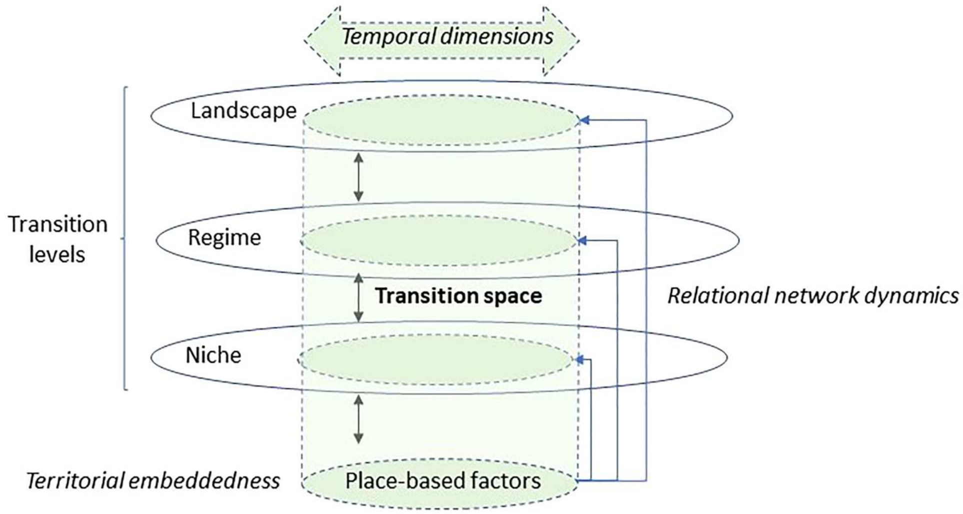

Fig. 1. A conceptual framework of a transition space combining territorial, relational and temporal transition dynamics

This article focuses on the interplay between place-based factors and transition levels as seen through the lens of a transition space. Our conceptual framework, which brings together territorial, relational and temporal transition dynamics, is summarised in Fig. 1. We apply the framework to analyse the GigaVaasa case, which represents the emerging battery industry in Finland.

Materials, methods, and case description

Building on the theoretical framework, we explore the case of an emerging battery industry's development in the empirical context of the Vaasa region, which is within the Ostrobothnia Region of Finland. The case study helps to analyse the diverse levels of the MLP framework and their connections to various place-based factors. The materials for our empirical analysis were drawn from various sources that provided relevant contextual knowledge on battery industry development in the Vaasa region. The materials included official reports, journal articles, and online publications (Table 1).

Our analysis of the GigaVaasa case was based on document analysis, which is considered a 'systematic procedure for reviewing or evaluating printed and electronic documents' (Bowen 2009, 27). We chose documents as our source data because they provided a comprehensive picture of recent developments in the emerging battery industry. Indeed, documents are increasingly adopted in qualitative research and represent existing naturally occurring realities within a study context (Morgan 2022, 64).

The procedures we followed for conducting the analysis first involved skimming the documents (i.e. superficial examination of them), during which we focused on searching for relevant publications (topics and abstracts) and official websites of institutions interested in battery development. Next, we complemented our preliminary findings with data from online local news media. The final analysis involved a thorough thematic analysis of all documents based on transition levels and categorising, and making sense of the data relating to our theoretical framework (cf. Bowen 2009).

Case description: battery development in the Vaasa region

We analysed the emerging battery industry in the Vaasa region to answer our second research question (RQ2) related to the role of place-based factors in GigaVaasa battery site development. Battery development in the region represents a new context and an interesting case for understanding the factors influencing the region's energy transition process, vis-à-vis battery production.

The Vaasa region consists of eight municipalities: Vörå, Isokyrö, Närpes, Malax, Laihia, Korsnäs, Korsholm, and Vaasa (VASEK 2024). The region is known for its energy cluster of over 160 local and international energy technology companies (Aslani et al. 2013a; EnergyVaasa 2019; Mäenpää 2021), such as Wärtsilä and ABB, which employ thousands of local people. Over 80% of the cluster's production goes to exports; thus, the region is one of the key economic areas in Finland (City of Vaasa 2024a). The renewable energy potential and supply chain, such as wind, solar and geothermal resources, are the key factors upon which the region's transition trajectory hinges (Aslani et al. 2013a). In 2023 the region was awarded the Community Award of the Year from the then president of

Table 1. Research materials and their relevance to the case study

Authors	Focus	Scope and relevance	Sources
Löfmarck et al. (2022)	Vaasa battery context	Account of the preconditions for developing the battery industry in the Vaasa region (e.g. natural resources' geographical origin, production facilities, and local, regional, and international supply chains and material flows)	Official report
City of Vaasa (2022); GigaVaasa (2022)*; Niemi (2023); Okonkwo (2022); Varjonen (2023); VASEK (2023)	Governance	Empirical account of actors' agency in battery developments (e.g. planning of land allocation, transport planning, engaging private investors, and completed and ongoing infrastructural projects in the region to strengthen access to the industry)	Journal articles, official reports, the website of a national media company, and regional actors in the Kvarken region
Aslani et al. (2013a); EnergyVaasa (2019); O'Sullivan (2022); Peura et al. (2022); Yorke et al. (2021)	Energy mix and discourses	Insights into the clean energy mix that can support the battery industry in the Vaasa region and the related discourses	Journal articles, the official website of a regional institution, an official report, and a local online newspaper
Aslani et al. (2013a; 2013b); Both2nia project (2022); City of Vaasa (2024a); EnergyVaasa (2019); GigaVaasa (2022); Haveri (2018); Löfmarck et al. (2022); Mäenpää (2021); Paasi (2012); Rasilainen et al. (2020); VASEK (2023); Virkkala et al. (2014)	Contextual background of the Vaasa region	Insights into factors (raw materials, strong institutions and facilities) that support the development of the battery industry in the Vaasa region	Journal articles, the official website of a regional institution, and an official report
City of Vaasa (2022); EnergyVaasa (2022); Löfmarck et al. (2022, 9); Mäenpää (2021); Ministry of Economic Affairs and Employment (2021); Virkkala et al. (2014); Wasaline (n.d.)	Governance	Shows the interdependence and interplay between actors in fostering the battery industry and provides insights into how established institutions shape local conditions	Journal articles, the official website of a regional institution, and an official report
EnergyVaasa (2019); European Commission (2022); GigaVaasa (2022); Haveri (2018); Löfmark et al. (2022); Merinova Technology Centre (2023); University of Vaasa (n.d.); Wärtsilä (2021)	Governance	Background to regional energy actors and educational institutions facilitating the industry's growth, explains how actors on different levels exercise various forms of agency	Journal articles, the official website of a regional institution, and an official report

Note: *The cited source refers to a downloadable brochure about EnergyVaasa, produced in 2019 with the title 'Establishing a battery factory', as accessed from GigaVaasa (2022). This applies to all references cited as GigaVaasa (2022) in this list

the Republic of Finland, in recognition of the region's strides in advancing energy transition through its energy cluster of companies (City of Vaasa 2024b).

GigaVaasa is a government-driven initiative by the City of Vaasa's administration to advance decarbonisation in the Nordic region through battery development, leveraging place-based factors. These include mineral deposits, energy infrastructure, energy technology companies and institutions (Löfmarck et al. 2022). Bridge & Faigen (2022) observed that the idea for establishing the GigaVaasa began around 2017. However, the goal, viewed from the network or organisation perspective (cf. Yeung & Coe 2015), is to enable cooperation among actors by providing governance for decarbonisation through the battery industry by creating favourable conditions for attracting investors (GigaVaasa 2022, see footnote 1). However, the goal is also to achieve a tangible product (the establishment of a gigafactory). In this context, the term gigafactories refers to 'large-scale facilities for lithium-ion battery production in which individual cells are fabricated, combined into battery modules and (sometimes) assembled as packs for a particular end user' (Bridge & Faigen 2022, 3).

Upon completion, the battery factory in the Vaasa region will further strengthen overall production capacity in Europe (Bridge & Faigen 2022). So far, GigaVaasa has been a successful initiative due to the active involvement of the city administration in the governance of the battery industry development process, which we elaborate more on in our empirical analysis (in the section '*Niche-level factors*'). The regional government has already mapped out four sites to be allocated to investors on 318 ha linked to the railway, airport and harbour (GigaVaasa 2022, see footnote 1), as shown in Fig. 2. The rationale is to provide a harmonised, well thought, and structured implementation of the location site to optimise access to the supply of raw materials and the market.

A recent example of maximising the type of battery production plants to be situated at a particular location involves the consideration by regional actors of situating new factories in areas with similar battery plants (Varjonen 2023). Accordingly, a new plot of land was recently reserved for a Chinese company to construct an anode material production plant in the GigaVaasa area (Varjonen 2023). Setting up the production plant has been estimated to cost 1.3 billion euro, with the construction completion date and inaugural operations set for 2026 (Niemi 2023). The factory would employ 1200 people for the entire operation (Varjonen 2023). With such a staff base, the annual production capacity has been projected to be 100,000 tons and to meet the rising demand

Fig. 2. A future industrial site for the construction of battery plants (Photo: modified and reproduced with permission from a downloadable brochure titled 'Establishing a battery factory', produced by GigaVaasa in 2019 (GigaVaasa 2022))

for storage solutions in low-carbon technologies, especially for electric vehicles (Niemi 2023). In addition, regional actors will liaise with investors through via GigaVaasa (e.g. they will liaise with the above-mentioned Chinese company to train staff for the operation of the proposed anode material factory) (Varjonen 2023).

Case-study results: the interplay of place-based factors and transition levels

Landscape-level factors

Historical evolution and market configurations are interlinked to the landscape level and point to a similar vision for the future. On a European level, the preliminary idea to rely on Chinese battery manufacturing has shifted, and there has been a growing dialogue on Europe's battery production in recent years (European Commission 2022). This has gained even more momentum since the Russian invasion of Ukraine and has spurred new interest in local energy solutions. Even before Russia's war in Ukraine, sustainability increased in importance on international and national agendas, spurring the global need for sustainable solutions. This shifting political interest in green technologies has boosted battery markets, which has created a greater demand for sustainable solutions based on electrification.

Electric mobility is a crucial avenue for reducing pollution and leads to increased demand for car batteries (International Energy Agency 2023). This has also been the case in Finland, as the national battery strategy focuses on ensuring that the importance of this new field is recognised (Löfmark et al. 2022) and has opened up opportunities for regime change and niche-level activities (e.g. GigaVaasa). Altogether, developments at the landscape level shape shared vision-building, which is intertwined with developments at the other levels.

Regime-level factors

When examining regime-level activities, the focus is on the alignment between technologies, policies, user patterns, infrastructures, and cultural discourses that have been created in previous decades (Geels 2019, 189); in the case of GigaVaasa they established the operating system that still exists today. This included the establishment of universities and energy companies in general, as well as their evolution into close institutional cooperation and its various forms in Vaasa (Aslani et al. 2013a, 406). This evolution has required efforts from all levels since the formulation of a regime always happens between landscape pressure and new niche activities. Mineral discoveries of cobalt and lithium could be categorised as originally niche activities, but their importance has since evolved.

Similarly, a new physical infrastructure, such as the energy laboratory at the Vaasa Energy Business

Innovation Centre (VEBIC), has been established at the University of Vaasa with the support of various partners, including the government agency Business Finland and the company Wärtsilä (University of Vaasa n.d.). In addition, Wärtsilä set up the Smart Technology Hub (today named the Sustainable Technology Hub, STH) to provide a needed space and meeting point for intellectual discussions and other scientific activities that would contribute to knowledge co-creation in the Vaasa region (Wärtsilä 2021). The interactions and collaborations have since occurred naturally due to the mutual need for research-based innovation, which shows institutional and cultural variation and institutional evolution. Over time, as trust and contacts have been formed, the educational system has been shaped to support the energy sector in terms of research, trained experts and a workforce (Haveri 2018). Today, the Vaasa region is regarded as one of the largest energy hubs in the Nordic region due to the agglomeration economics of energy companies over time. The agglomeration over time shows a collective sociocognitive orientation towards global energy markets (cf. Coenen et al. 2012).

Although the local innovation system is company-driven (Virkkala et al. 2014), there has been a long tradition, especially in the energy cluster, of collaborating and working together to attract talent to the Vaasa region, such as during the annual EnergyWeek conference and festival (EnergyVaasa 2022). Indeed, talent attraction is seen as a significant challenge for the future of the battery industry (Löfmarck et al. 2022), which might benefit from collaborating with other energy companies in the field. This shows how certain socioeconomic factors (energy-related and manufacturing-related experts) favour the energy cluster.

The Vaasa region appears favourable for utilising renewable energy, which is essential for sustainable battery production. For example, hydrogen technology is being developed in the region and its surrounding area, which shows industrial and technological potential for new energy markets (Both2nia project 2022). Furthermore, the region is one of the early adopters of different types of green technologies, such as hydropower and wind, which are facilitated by various energy companies operating in the region (Aslani et al. 2013b). Additionally, the region has been looking at electric aviation and how it could affect the region, which would link it with broader transportation and e-mobility solutions. Furthermore, transportation planning has played an important role in supporting the emerging industry in GigaVaasa (cf. Bridge & Faigen 2022). Also, regional development agencies are actively planning to increase regional transport connectivity (Okonkwo 2022).

Niche-level factors

Regarding niche-level activities, we looked more closely at GigaVaasa in relation to other levels and several place-based factors connected to its development. The Vaasa city administration together with its colleagues from Korsholm Municipality established a strategic land-use planning and permitting process to ensure adequate land utilisation for further development of the emerging battery factory site. Some tangible efforts that have progressed well include completing infrastructural projects, such as roads, to support the development process (City of Vaasa 2022).

Gauging the interests of investors and actively engaging them in negotiations has been a vital aspect of governance (VASEK 2023). Several preliminary contracts exist for companies such as FREYR Battery, Finnish Minerals Group, and Epsilon Advanced Materials (VASEK 2023). Furthermore, it has been suggested that GigaVaasa has the potential to increase work-related immigration and thereby attract the working-age population, which would be likely to have a positive effect in the real estate sector due to the envisaged increased demand for housing (Kuivasmäki 2023).

The Regional Council of Ostrobothnia, alongside municipalities, has included battery production in its policy portfolios consisting of regional development programmes, related strategies, and development projects, which may thus be supported by European development funds (Regional Council of Ostrobothnia n.d.). Furthermore, through its agencies, the Vaasa region is actively involved in the Nordic Battery Belt initiative, which represents a cross-border approach to public–private partnerships on green innovations (Okonkwo 2022). Thus, local policymakers have not just acknowledged the new industry but have already adopted it. The planned strategic location of the battery production site is expected to give the Vaasa region a competitive advantage in the supply chain process, such as transporting raw materials and finished products (O'Sullivan, 2022). The planned battery production site is 12 km south-east of the harbour and 1 km east of the airport. By comparison, the lithium carbonate deposit is 140 km north-east of Vaasa, and other essential natural resources, including cobalt, nickel and graphite, are readily accessible (EnergyVaasa 2019).

Besides the vast raw materials in the Vaasa region and areas within proximity, many battery-related companies and projects are springing up in the region due to the availability of clean energy production (EnergyVaasa 2019), which can be considered an important regional industrial capability. Vaasa's electricity system was recently updated from 220 kV electricity grids to

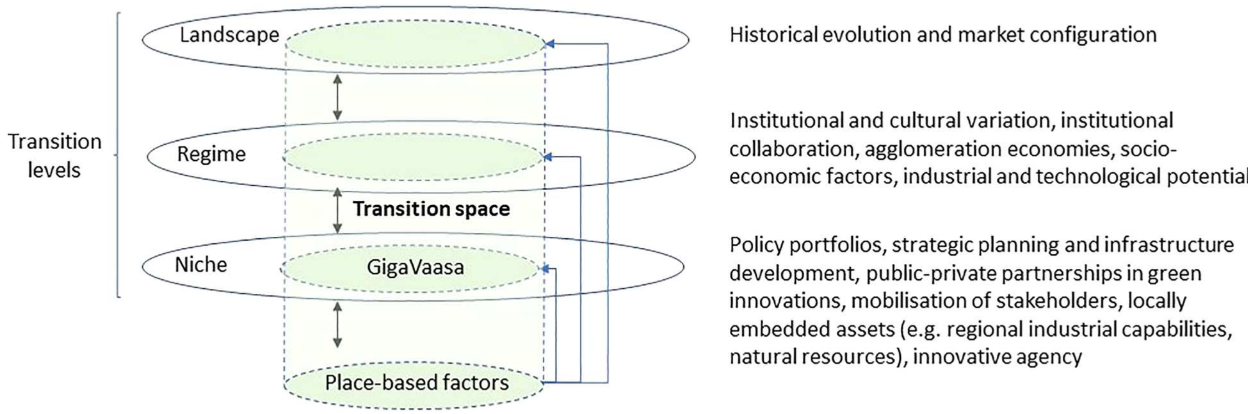

Fig. 3. Place-based factors in the case of the GigaVaasa battery industry and their connections to diverse transition levels

400 kV transmission lines and substations to meet the high energy demand of the industrial sector (Aslani et al. 2013a; Haveri 2018), further advancing the region's industrial and technological capabilities. Lastly, the region has mobilised stakeholders for joint energy innovation projects. One concrete example is the ship *Aurora Bothnia*, the world's most energy-efficient passenger vessel (Wasaline n.d.). The ship was acquired by both public and private actors in the region, and it acts as a living laboratory for several local companies that had originally provided their products to build the ship. It operates between Vaasa and Umeå, and shows how the region values new energy-related innovations and their use in practice.

Discussion

Our analysis of the GigaVaasa case shows how niche-level activity started its pathway towards battery production to provide solutions to the changing mobility regime. As we have identified several place-based factors that play a role, we have aimed to clarify on which level they operate in the GigaVaasa case. We have categorised the different place-based factors under the transition levels to analyse how place-based factors interact with transition levels in a transition space and which of them appear relevant for the energy transition. The categorisation of different place-based factors in relation to transition levels is summarised in Fig. 3.

The MLP theory advocates that change cannot happen without landscape-oriented interference, which allows new niche actors to reach the regime level (Geels 2006; 2019). This description seems valid for battery production in Vaasa too. The increasing worry about climate change, increasing green markets for electrification, and the changing geopolitical landscape have made European battery manufacturing more favourable. In turn, the need for a new regime in which local European battery solutions would play a more prominent role has increased, which means that markets and landscape levels are an essential starting point for change.

The regime level in transportation quickly adapts to new markets and forms an essential background for niche-level activities. Institutional collaboration and recognised industrial and technological potential have already been established. This reminds us of the importance of incremental and institutional change (Martin, 2010). For example, the GigaVaasa factory site was a result of a long-term and ongoing development process and an active agency of Finnish actors who had created an ambitious vision for the development of the emerging battery cluster in the region, initially attempting to attract the American company Tesla to establish a new European factory in Finland (Puikkonen 2017). This leads us to the niche level, where most place-based factors play a role.

One way to activate local stakeholders is through strategic planning and stakeholder mobilisation, as in the GigaVaasa case. Once the landscape and regime-level conditions were recognised, it was possible to start a process in which a suitable site for a battery factory could be planned. The existing knowledge base, raw materials, and energy are critical place-based factors supporting battery production on a local level. The role of regional industrial capabilities and raw materials has been seen as important also in the regional transportation literature concerning materiality (e.g. Trippl et al. 2020).

It is notable in Vaasa's case that the place-based factors link the battery site with all the transition levels. This highlights the potentially broad and versatile scope of its transition space, which may offer opportunities for several transition pathways, some of which might be more landscape or niche oriented (Geels & Schot 2007; Geels 2019). The existing development of the battery site correlates with the regime transformation pathway (Geels & Schot 2007), except that this realignment happens more on the niche level than the regime level. Additionally, our study indicates that the MLP and the related notion of external pressure are not entirely invalid as they can be seen as helping new niche-level activities, like GigaVaasa, towards transition in the transportation regime.

All three dimensions of the transition space – territorial, relational, and temporal – coexist and are intertwined in the GigaVaasa case. The emergent battery industry site is embedded in territorial assets and development policies, building on collectively identified place-based potential. However, the local initiative operates as a part of a relational transition space intertwined with national and international network dynamics. Furthermore, multiple temporalities coexist in the transition space as processes of path creation in the energy field have decades-long roots, yet recent developments (e.g. in the European security environment) have created momentum for the initiative. In light of Pittaluga's synthesis of possibilities of transition spaces (Pittaluga 2020), the GigaVaasa case demonstrates strategic yet flexible appropriation, orientation and management of the transition space, combined with attempts to increase diversity that is seen as crucial for attracting future workforce to the region.

Conclusions

This article contributes to the geography of transitions literature by (1) advancing the nascent theorising on the concept of a transition space (Coenen et al. 2012, Pittaluga 2020) in the context of geographical transition studies through a novel theoretical framework that connects place-based factors to diverse transition levels, and (2) applying the framework to study place-based factors and their various interactions with transition levels through a case study of the GigaVaasa in Finland. We have presented a conceptualisation of a transition space as a three-dimensional space that combines territorial, relational, and temporal transition dynamics, and showed that different place-based factors may interact with transition levels in a transition space. A relational view of place-based factors contributes to ongoing debates on the governance of transitions, as the importance of a place-based approach in governing societal transitions is increasingly being emphasised in transition studies and effective policy implementation (e.g. Bianchi et al. 2024).

Our case study of Finland's emerging battery industry demonstrated that multiple place-based factors are relevant to an energy transition. The results indicated that multiple place-based factors connect with different transition levels in a transition space, enhancing their possibilities for leveraging transition pathways. As multidimensional phenomena, energy transitions are not solely dependent on one place-based factor but are based on their recombinations and spin-off activities (Trippl et al. 2020). In addition to raw materials, attracting local talent, institutional elements, and market configurations play significant roles in the broader energy transition. Some of the most remarkable place-based factors arising from the case are related to local strategic planning and stakeholder mobility, which form a critical starting point for successful transition space management. Early on, regional officials started negotiations between several local and national actors to evaluate the creditability and potential of the GigaVaasa site. This form of local enterprise relates to systemic agency (Trippl et al. 2020) and the ability to recognise trends and openings at the higher transition levels, as well as knowledge of individual actors at the niche level. Hence, the examined place-based factors had versatile connections to all transition levels, having various territorial, relational and temporal characteristics. A place-based approach to governing energy transition can be recognised from the case, connecting a rather distinctive institutional environment (forming from cluster stakeholders and other local actors) and the ability to utilise individual-, collective- and system-level agency with an understanding of the potential of materiality and land use. All of this led to the initial plan for the GigaVaasa site, where the relational presence of several place-based factors at broader transition levels subsequently improved the possibilities to catalyse development at the site (cf. Bathelt & Glückler 2005).

Our study has some limitations that need to be recognised and considered in future research. The battery cluster in Vaasa is still being built; hence, document analysis was a way to look at the plans and developments at this stage, which could be enhanced via interviews. The data sources had some limitations in their coverage because they mainly discuss the topic in a positive light; hence, future studies should deepen the critical analysis of the emerging battery industry. It is also essential to recognise that there may be situations where place-based factors may hinder or stop a transition. Another research need is to deepen the empirical analysis related to understanding the path creation processes behind the emerging battery cluster. Meanwhile, the analysis of links between geographical scales and transition levels should be deepened, as it is beyond the scope of this article to discuss this topical research problem. Understanding the multiple connections of place-based factors to various geographical scales within the European governance scheme is essential to clarify roles and responsibilities in the future (McCann & Soete 2020). As this article is among the first to conceptualise transition spaces within the context of geographical transition studies, further theoretical and empirical work is needed to explore the potential and limitations of the concept in different contexts. Rather than being viewed here as an ontological issue, territorial boundedness presents a contextual–empirical lens that provides a means through which to study complex and spatially diverse transition dynamics and their place-based connections (cf. Paasi 2012).

Despite the identified limitations, it is crucial to deepen the understanding of the place-based factors that support the battery industry because they are essential for advancing energy transitions. Such knowledge could lead to improved prioritisation and streamlining of regional policies. The case from the Vaasa region of Finland is interesting, as several place-based factors contribute to the emergence of the battery industry and broader transition, making the region well suited for sustainable energy production and broader lesson drawing. In the future, critical attention needs to be paid to broadening the knowledge base of policymaking and enabling broad participation throughout the region. This is because harnessing place-based potential in economically, socially and ecologically sustainable ways is inherently intertwined with the democratic legitimacy of place-based transitions.

Disclosure statement

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