

An overview of the Nordic Battery Belt: an emerging network for cooperation within the Nordic battery cluster

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There is an increasing global demand for batteries in the decarbonisation process and an attempt to increase its production within Europe, thereby reducing the dependency on the Asian market. Consequently, the battery industry cluster is emerging in the Nordic region with the requisite raw materials for battery production in Norway, Sweden, and Finland. The industry will encounter medium- and long-term challenges in its supply value chain due to the envisaged transport connectivity issues in the region, especially as the industry begins experiencing growth. Regional networks will play a key role in mitigating these challenges by providing a space for cooperation among actors; however, how regional networks address these transport connectivity issues still needs to be explored. This paper introduces results from a qualitative study that adopts the network approach in examining the nature and the role of a novel network within the Nordic battery cluster. They show that the Nordic Battery Belt (NBB) is an emerging cross-border regional network established to proactively identify the prevailing and the envisaged connectivity challenges within the Nordic region. The NBB, therefore, contributes to the development of logistical strategies and inventories for sustainable and cost-effective transport systems, which will support the battery industry's supply chain and reduce the industry's carbon footprints. Overall, the paper advances the understanding of networks and their role in the regional energy transitions literature viz-a-viz the battery industry.

Keywords: battery industry, regional energy transitions, cooperation, network, Nordic Battery Belt (NBB)

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Introduction

Batteries are innovative technologies expected to play an increasing role in the decarbonisation process via the reduction of the intermittency of renewable energy while also contributing to economic growth and environmental sustainability (Stephan *et al.* 2019; Halleux 2022). As the demand for batteries in the decarbonisation process continues to increase, battery industry cluster

is emerging in the Nordic region, including Norway, Sweden, and Finland, to meet this increasing demand (Löfmarck *et al.* 2022). Following this development, new regional networks have been established to strengthen the industry cluster (Kvarken.org 2021a). Europe accounts for 17% of the global demand for batteries; a sector projected to be worth over €250 billion annually by 2025 (Halleux 2022). Due to the strategic importance of batteries in Europe, it has become imperative to scale up battery production through a range of measures that covers “raw materials extraction, sourcing and processing, battery materials, cell production, battery systems, reuse and recycling” (*ibid.*, 2). In the Nordic region, increasing investment in the battery industry to support an accelerated decarbonisation process is taking place. While this could be considered a good move towards the right direction, Murphy and Smith (2013) observe that inadequate infrastructural development could hamper access to natural resources and their optimal utilisation. Against the backdrop that the Nordic battery industry is envisaged to face medium- and long-term transportation challenges in its supply value chain due to the inadequate transport connectivity in the area where the battery factories are domiciled (Löfmarck *et al.* 2022).

While burgeoning research on the role of batteries in the decarbonisation process exists, some of which highlights the importance of cooperation in battery development among the private sectors. However, within the Nordic context, the transport connectivity challenges in the emerging battery cluster and the role of regional networks in solving them remains underexplored. This paper is a qualitative case study that utilizes secondary data to examine a novel regional network referred to as the Nordic Battery Belt (NBB) to understand the reason for its emergence, nature, composition, and role in strengthening the transport connectivity of the battery cluster. In addition, network perspective will be utilized to facilitate the understanding of the NBB and will be conceptualised herein as “deliberately designed and intentional structures, instruments or tools that are voluntary constructions” (Hoppe & Miedema 2020, 6). The emerging battery cluster and the concomitant regional network will open a new space for regional cooperation towards solving the medium- and long-term transport connectivity challenges projected to confront the industry (Löfmarck *et al.* 2022). As shown in the paper, there is a surge of battery cluster within the Nordic region albeit with envisaged transport connectivity challenges. This being the case, a cross-border regional network hereafter refers to the Nordic Battery Belt (NBB) was established to improve the industry’s supply value chain and strengthen the links to the European and international energy market. Its main objective is to develop an effective logistical strategy that will foster a sustainable cluster thereby improving the sector’s competitive advantage (Kvarken.org 2021a). This study increases the understanding on the role of networks in the decarbonization process *viz-a-viz* developing an effective logistical strategy considered essential in fostering a sustainable battery cluster and regional energy transitions particularly within the Nordic context. The paper is composed of the following sections: a review of related literature, theoretical underpinning, an empirical background of the battery cluster in the Nordic region, a description of research materials and methods, introduction of results, followed by a discussion, recommendation, and conclusion sections.

Mind the gap: the role of cooperation in advancing the battery industry

Battery production is a complex process that involves the interaction of different institutional stakeholders (Liu & Agusdinata 2020). Multidisciplinary expertise and interdisciplinary collaborations of actors are required to address the challenges in battery development (Booth *et al.* 2021). Some of these challenges include carbon footprints (Peiseler *et al.* 2022). Others include additional emissions in storing electricity in new battery technologies (Schmidt *et al.* 2019). While lack of comprehensive regulatory framework for battery waste management has also been identified (Dobrowolski *et al.* 2021). Studies have also shown that part of these challenges include health and safety hazards (Tang & Yuan 2021). In addition, low battery performance and longevity issues of battery cells remain one of the main issues affecting the efficiency of batteries (Robinson *et al.* 2021). Cooperation and collaboration are also imperative for meeting the increasing demand for batteries in Europe while at the same time reducing the dependency on the Asian battery market (Beuse *et al.* 2018). Additionally, cross-sectoral knowledge is considered as an essential factor in developing such an important modern

technology (Stephan *et al.* 2019). One of the ways to achieve knowledge co-creation is through effective and inclusive multi-stakeholder participation and continuous dialogue in the policy process, which among other things, increases the sustainability of the battery industry (Petavratzi *et al.* 2022, 19). Other benefits associated with active stakeholder involvement is its ability to accelerate the pace of diffusion (Stephan *et al.* 2019). Studies suggest that private (actors) project developers play an essential role as the first mover in the diffusion of renewable technologies (Steffen *et al.* 2018). Network actors are also involved in framing policies for local technology learning to reduce implementation costs. They also contribute to improving knowledge by contributing to the technology standardisation process, permitting processes, grants, and public procurement (Neij & Nemet 2022).

Meanwhile, other studies relating to cooperation in strengthening the battery industry have focused mainly on the role of the private sector actors in the technology development aspect of the battery industry rather than on the role of regional networks in solving connectivity challenges. For instance, these studies have dealt with issues in the following areas: collaborative and interactive learning in the private sector among “material suppliers, production equipment manufacturers, cell manufacturers, system integrators and end users, with cell manufacturers acting as a central node for coordination of inter-sectoral learning” (Malhotra *et al.* 2019, 478). Furthermore, collaboration among private actors working with wind technologies, solar Photovoltaics (PV), and biomass is well known (Steffen *et al.* 2018). Another area that has been investigated is the knowledge exchange between private sectors involved in developing, producing, and using unique technologies (Stephan *et al.* 2019).

The imperativeness of strengthening the sustainability of the battery industry through capacity building is also well noted. For example, the closest attempt that examined issues relating to infrastructural development that supports the transportation of battery raw materials points to the negative impact such infrastructural development could have on biodiversity (Petavratzi *et al.* 2022). Besides the practical sustainability challenges with infrastructural development, the study also suggests other diverse challenges within the industry, such as poor institutional connectivity and low stakeholder participation, regarded as governance challenges with implications for poor data management in accessing the environmental impact of battery production. For instance, the study shows that inadequate investment in infrastructural development is one of the economic and social challenges for battery production as it not only hampers the supply value chain but also leads to opposition from local communities who expects that infrastructural development will naturally constitute one of the positive externalities for battery-related activities in their local communities. On that account, this suggests the importance of infrastructural development for the efficient operation of the industry; yet the study does not provide insight into how network actors are working to address these infrastructural challenges. The preceding thus constitutes noticeable gaps that require further examination. As already stated, there are burgeoning studies related to batteries, as can be deduced in the studies outlined above, and they provided important insights into understanding the importance of cooperation among actors within the industry. Despite these contributions by previous research, studies that deal with the role of regional networks towards strengthening the transport connectivity and the supply chain within an emerging battery context have been underexplored.

The rationale, and process for selecting the Nordic Battery Belt in this study

Based on the observed gaps, this paper examines an empirical case relating to the nature of a novel regional institution, the Nordic Battery Belt (NBB), established to strengthen the battery cluster. The NBB aims to develop transport strategies that address the projected medium-and long-term connectivity challenges within the Nordic context where the industry is domiciled (Löfmarck *et al.* 2022). The following questions guide the study that aims to increase understanding of the role of networks in proffering solutions to the transport connectivity challenges; *How can the nature of the NBB be understood through the Network theoretical perspective? Why is establishing the NBB important in the emerging Nordic battery industry?* This paper is based on a qualitative study of the Nordic Battery Belt (NBB) composed of actors from three Nordic regions of Nordland, Norway; Ostrobothnia, Finland; and Västerbotten, Sweden, respectively. The actors from these regions include the Kvarken Council EGTC, Vaasa Region Development Company VASEK, Skellefteå Municipality, Kokkola Region

Development Company KOSEK, Rana Utvikling, and MidtSkandia. I used tables and diagrams to ensure an easy understanding of the information presented in this paper (cf. Belt *et al.* 2011).

The NBB was selected because the research aims to increase the knowledge of the role of regional networks in the Nordic battery cluster. I adopted qualitative methods to ensure an understanding of a phenomenon in different contexts (Bengtsson 2016). I searched for journal publications related to the research topic using 'battery' and 'institutions' as keywords in the 'Title' field with the Boolean operator 'AND' for articles collected in Scopus published in the last five years from 2018 to 2022. These papers were selected because they represent the latest research on network and institutional aspects of the battery industry. The initial search that cut across different disciplines displayed 1 350 results. Since some results were unrelated due to their disciplinary affiliations, I streamlined the search by selecting only the most related fields that fit the research topic, such as innovations, technology, and social sciences. In doing so, I further reduced the results to 228 articles from which I selected the final literature used in the study. By doing so, only the most relevant articles were included in the paper, allowing for in-depth reading of the documents before I made the inclusion and exclusion decisions. The selection criteria include articles with some of these keywords either in the topic or in the abstract: battery, networks, electrification, energy storage, innovation, and institutions. Also, I included only regularly published articles written in English due to the scope of the researcher's language proficiency.

In addition, I used official conference reports that provided an empirical contribution within the research context and data from official government and private companies websites. For instance, I extracted the perspectives of some regional actors on the NBB from the information available on Kvarken.org because they have the most updated information on the NBB attributable to their role as the coordinator within the emerging network. Furthermore, I gathered information that provided the contextual understanding of the constituting actors in the NBB through the official websites of other actors such as VASEK.fi, Skelleftea.se, KOSEK.fi, RanaUtvikling.no, regionvasterbotten.se and Kvarken.org *et cetera*. The rationale for utilising different secondary data sources was to ensure the triangulation of perspectives for improved undertraining of the phenomena (cf. Lune & Berg 2017). Lastly, the Network theoretical framework facilitated the understanding of the importance of human factors in the transition process, while content analysis augmented the secondary data analysis. Content analysis is "a research technique for making replicable and valid inferences from texts to the contexts of their use" (Krippendorff 2018, 18). Also, context analysis facilitates making sense of collected data and reaching conclusions, ensuring research rigour, credibility, and trustworthiness (Bengtsson 2016). Since this paper aims to provide an overview of the NBB rather than understanding the cooperation processes within the NBB; hence, it relies solely on secondary data. Although this is not to say that primary data collected via semi-structured interviews of some of the actors in the NBB could not have increased our insight into the stakeholders' perspectives regarding the industry and the regional network. I compensated for this limitation by utilising a recent official report based on empirical findings viz-a-viz the NBB to increase the understanding of the emerging network.

Network theoretical perspective in regional energy transition

Networks play a crucial role in context-based innovation policies that support the diffusion of new cluster at the regional level (Fornahl & Hassink 2017). These policies also influence the direction and pace of the diffusion of technological innovation (Stephan *et al.* 2019). Network theoretical perspective is utilised in regional transition studies to understand the role of actors in the decarbonisation process (Hoppe & Miedema 2020). In addition, it facilitates the understanding of the contribution of networks to the policy process (Klijn 2008). As well as their role towards solving complex societal problems (Van Bueren *et al.* 2003). Network theoretical underpinning also offers a perspective from which to analyse technological developments (Lee & Su 2021). The theory also support the claim that the energy transition is accelerating due to human factors, such as increasing collaboration and coalitions among actors (Sovacool *et al.* 2020). Put differently, the human factors can be understood as collaboration among "different actors operating at various scales in activities that influence a region's transition" (Coenen *et al.* 2021, 223).

Context-specific factors such as political conditions, economic structures, and available material resources influence the nature of a formed network (Fuchs & Hinderer 2014). These initial contextual conditions affect the policy intervention adopted (Fornahl & Hassink 2017, 3). That being the case, networks can be seen as "deliberately designed, intentional structures, instruments or tools that are voluntary constructions, and are not the result of a mandate from an external actor" (Hoppe & Miedema 2020, 6). Policy networks, for instance, are made up of multiple interdependent actors (Lee & Su 2021). There is also structural dependence of members and the absence of subordinates (Turrini *et al.* 2010). Within a network, members participate equally in managing the affairs such as decision-making, goal setting, strategy, planning, and so on (Hoppe & Miedema 2020, 7). A network's overall objective is to attain a win-win goal for its members through a combined utilisation of resources, alignment of interests, goals, actions, commitment, and compliance of actors, as well as openness in interaction (Hoppe & Miedema 2020). Network actors collaborate with other actors through exchanging ideas and resources (Lutz *et al.* 2017). Trust within the network has also been identified as an essential factor that enhances and sustains cooperation (Klok 2018). Individual actors within the network usually have predefined goals they want to achieve, and this motivation influences their level of commitment (Fuchs & Hinderer 2014).

In most instances, network actors are within close geographical locations and possess similar economic contexts, such as raw materials and well-established infrastructure (Lutz *et al.* 2017; Milward *et al.* 2010). Empirical studies suggest that some countries, although in proximity, differ significantly in their "levels of development, governance regimes and strategies for the exploitation of raw materials for battery production" (Petavratzi *et al.* 2022, 15). Other studies suggests that this is not the case within the Nordic region as they have similar contexts and a robust historical cooperation tie (Löfmarck *et al.* 2022). Networks also play an imperative role in the formation of clusters and the latter contributes to a region's development (Fornahl & Hassink 2017, 2). They also argued that "clusters are not closed entities but are embedded within an ecosystem of networks, actors, linkages, rules" (*ibid.*, 3). Lastly, for these scholars, networks and their policy intervention ensure the sustainability of clusters and their ability to renew themselves, thus preventing their decline.

The emerging battery cluster and the need for cooperation in the Nordic region

As the demand for batteries to support the decarbonisation process continues to increase, so are the emerging battery industries at different places to meet these demands. Within the EU, one of the decarbonisation strategies is to reduce the dependency on the Asian market for its supply of battery products and services within the sector (Beuse *et al.* 2018). Hence, many European countries and regions have begun looking inwards to align their decarbonisation strategies with the increased utilisation of available local resources. Within the Nordic context, three countries comprising Norway, Sweden, and Finland, are experiencing a surge in battery industries (Löfmarck *et al.* 2022, 3). One of the driving factors is the availability of the natural raw materials needed to produce batteries, such as cobalt, nickel, lithium and graphite, copper, vanadium, and other critical materials (*ibid.*) Hence, it follows naturally that the energy transition strategies in the Nordic region would support the increased utilisation of these available local resources. Besides these resource endowments, several other factors help the surge of the battery industry in the Nordic region such as the availability of clean energy (EnergyVaasa 2019). Transport infrastructure and effective regional institutions are also some of the crucial factors that support the battery industry (Löfmarck *et al.* 2022).

Based on the economic prospects and the favourable conditions to operate in the region, an increasing number of companies have indicated interests in investing in the battery industry. Already, some companies have completed the construction of battery production plants and have begun operations, such as the Northvolt plant in Skellefteå, the Kedali Industry and Boliden battery industry projects in Sweden (Löfmarck *et al.* 2022). The building phase is underway in Mo i Rana, Norway, by Freyr, a Norwegian-based battery company. While in the Vaasa region in Finland, the planning phase to construct a battery factory is already in full swing as different companies have expressed interest, such as Grafintec, which intends to build an anode material plant in Vaasa; also, Keliber, a company domiciled in Kokkala plans to construct a lithium hydroxide plant (*ibid.*).

The growth of the battery cluster in the Nordic region hinges on the fact that the three countries not only share proximities but also have similar contexts such as governance structure and strong institutions, level of economic and infrastructural development and a solid historical tie of cross-border cooperation (Aula *et al.* 2020). Empirical reports suggest that although the Nordic region has a well-established transport infrastructure, this does not negate the absence of connectivity issues orchestrated by inadequate infrastructures such as roads, rail lines, and seaports connecting especially the East-West areas that can adequately support the industry in the long term (Löfmarck *et al.* 2022). Given the proximity and similarity of contexts, the battery cluster will face similar connectivity challenges that could impact the supply value chain of the emerging industry in the medium and long term as the sector starts experiencing increased growth in the next few years. For instance, the report claims that while the current state of the existing infrastructure in the next three years is adequate in ensuring the operations of the supply value chain, it is still vital to improve them further to serve the needs of the growing industry.

Solving the identified connectivity challenges require Nordic cooperation and collaboration among regional actors (Löfmarck *et al.* 2022, 53). Studies regard this form of cooperation as an “umbrella term for the system of norms, international organisations, treaties and agreements, formal and informal contacts, and common projects and customary procedures” (Landiss 2012, 4). Nordic cooperation also facilitates the establishment of strong ties in achieving mutual socio-economic and political objectives, overcoming common challenges, maintaining economic and political cohesion, legitimising issues of common concern, and fostering unity and recognition of shared cultural heritage (Notaker 2022). This form of cooperation usually takes place loosely through networks and within various sectors; it promotes learning, knowledge exchange and harmonised policy positions between member states, it also adopts a “bottom-up approach characterised by informal networking and coordination among national administrations and stakeholders” (Stie & Trondal 2020, 5). Deep integration, weak disintegration, and differentiated integration are the three main forms of cooperation among the countries in the region (*ibid.*). Differentiated cooperation ensures that different regional institutions collaborates on different policy issues and at varying times and pace (Leruth *et al.* 2019). The NBB can be regarded as a cross-border network with an element of differentiated cooperation because it connects three countries within the region, with the aim of addressing common (transport connectivity) challenges or ‘crises’ in the battery cluster. Overall, the emerging battery industry in the Nordic region has a reasonable prospect based on the factors already outlined, and cooperation within the network (NBB) will further strengthen the industry’s competitive market advantage as well as reduce the carbon footprints by shortening the transportation distance within the battery cluster supply chain.

An insight into the Nordic Battery Belt

This section presents the nature and role of the NBB, as well as the perspectives of key stakeholders concerning the emerging battery industry. Three regions comprise the NBB: Ostrobothnia, Nordland, and Västerbotten in Finland, Norway, and Sweden, respectively (Löfmarck *et al.* 2022). In a nutshell, Figure 1 below captures the composition and objectives of the NBB.

As shown in Figure 1, the Nordic Battery Belt is a cross-border network comprising different cross-regional actors such as the Kvarken Council EGTC, the Vaasa Region Development Company VASEK, Skellefteå Municipality, and the Kokkola Region Development Company KOSEK. Rana Utvikling, MidtSkandia, and Future Cleantech Solution. The composition of the NBB reinforces the claim that regional energy transition is a complex process. Studies have also shown that different actors often cooperate to achieve common goals in the decarbonisation process (Droege 2018). The NBB plays an imperative role in the decarbonization process by identifying the envisaged medium- and long-term logistical issues that will likely affect the supply value chain within the Nordic battery cluster. The aim is to ensure sustainable and cost-effective transportation of human and material resources, which could also ensure reduced carbon footprints of the industry (Löfmarck *et al.* 2022). In addition, the NBB works towards removing barriers to cooperation in the regional market by developing logistical strategies and inventories to strengthen the battery cluster in the region (Kvarken.org

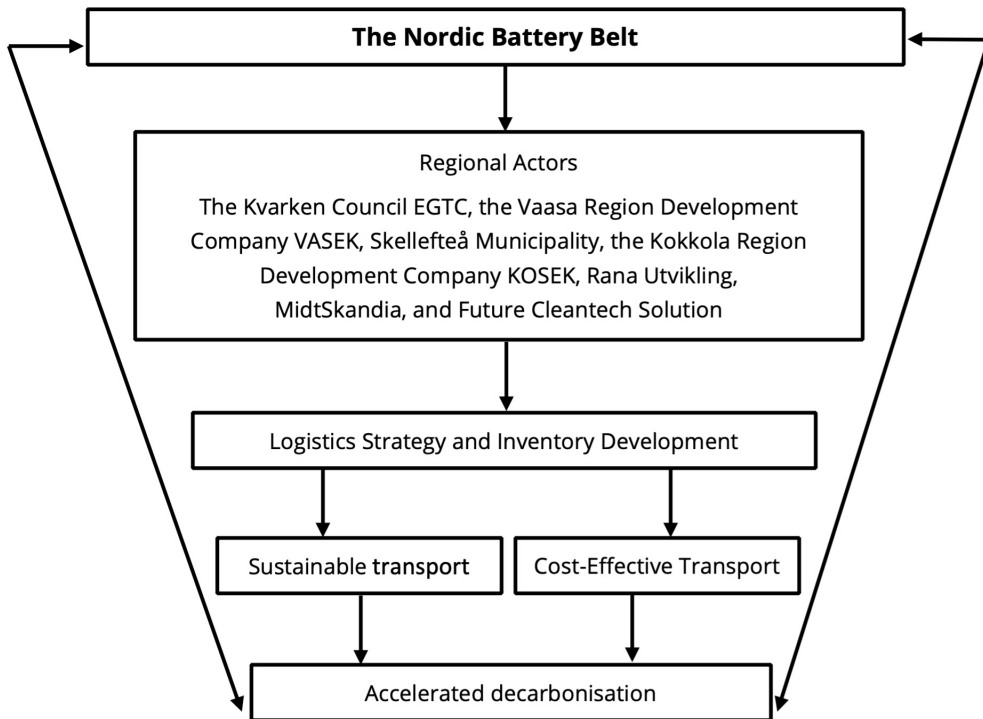


Fig. 1. An illustrative summary of the Nordic Battery Belt (NBB).

2021a). Against this backdrop, "inter-organisational relation is important for the formulation of joint vision or establishment of collaborative innovation projects" (Hansen & Coenen 2015, 100). Therefore, developing transport strategies to address the anticipated connectivity challenges will contribute towards ensuring the sustainability of the battery cluster. Some of the identified connectivity challenges to be addressed include the following:

Missing railway link between Storuman (Sweden) and Mo i Rana (Norway); Underway but needs to be completed: Norrbotniabanan between Umeå in the south and Luleå in the north (Sweden); Road conditions in Sweden (E4 is planned to be redrawn around Skellefteå, but east-west roads over to Norway are considered poor; E12 is an essential east-west connection); Railway capacity between Ylivieska and Oulu (Finland); New port road in Vaasa (Finland); Widening and deepening the fairway to Vaasa (Finland); Widening and deepening the fairway to Mo i Rana (Norway); Developing digitalisation as a competitive advantage in all countries; Infrastructure for electric air traffic possible is needed in more airports; also vertiports for eVTOLs / could solve certain goods transport issues. (Löfmarck *et al.* 2022, 4).

As already stated, batteries support the decarbonisation process. While such a transition presents substantial economic opportunities for the Nordic countries, it is pertinent to invest towards an improved infrastructure that would contribute to the growth of the battery industry. The connectivity challenges outlined above are gradually receiving attention to ensure the development of enhanced logistical infrastructures and solutions that will strengthen the battery value chain in the Nordic region. Despite the progress that has been recorded so, more needs to be done because "many areas in Finland still need improved connections to the European and international market; thus, a fixed link across the Kvarken would benefit all three countries – not only Sweden and Finland but also Norway" (Kvarken.org 2021b, 2). Improving the transport infrastructure and connectivity will enhance the movement of goods and services in the battery-producing region and strengthen the value chain of the battery cluster (*ibid.*). It is imperative to note that such developmental activities will present opportunities and challenges, hence, the need for multi-stakeholder involvement (NordicHub 2021).

Solving the identified issues would require increased cooperation among regional actors; the NBB will thus contribute to increased cooperation among key stakeholders through the various knowledge co-creation events and discussions it organises that improves the business growth in the Nordic energy market (Löfmarck *et al.* 2022). To gain more insight, Table 1 provides an overview of the actors that constitute the NBB.

Table 1. Regional actors within the Nordic Battery Belt.

Actors	Objectives	Focus
The Kvarken Council (Kvarken region)	Provides a platform for cooperation for regional actors; eliminate border barriers (Kvarken.org).	Transport, business, education, research and development, culture, environmental issues (<i>ibid.</i>).
Vaasa Region Development Company (VASEK)	Improves the precondition for business activities in the Vaasa region (VASEK.fi).	Business development services, regional development, marketing (<i>ibid.</i>).
Skellefteå Municipality (Västerbotten, Sweden)	Provides favourable conditions for a thriving battery industry (Skelleftea.se).	Municipal administration and active involvement in the development of the battery industry (<i>ibid.</i>).
Kokkola Region Development Company (KOSEK)	Pro-bono business and development Services for all entrepreneurs and companies (KOSEK.fi).	New entrepreneurship, operating companies, business transfers (<i>ibid.</i>).
Rana Utvikling (Nordland, Norway)	Facilitates new commercial activities and improve operations for the business community (Rana Utvikling.no).	Free consultations and support services to start-ups and companies in the region (<i>ibid.</i>).
MidtSkandia	Improves transport and logistics solution in the east-west direction (Regionvaesterbotten.se).	Advocacy for infrastructural development, skills supply, innovation, entrepreneurship, and sustainable energy development (<i>ibid.</i>).

As shown in Table 1, the Kvarken Council functions as a neutral network that enables different types of cross-border cooperation. It currently plays a coordinator-like role in fostering regional cooperation, especially within the NBB, and increasing the region's visibility at the national and European levels (Kvarken.org 2021c). The second actor is VASEK, located in the Ostrobothnia region in the Western part of Finland. The Vaasa region is considered one of the energy clusters in the Nordic countries (EnergyVaasa 2019). VASEK works primarily as a facilitator for emerging businesses; they promote and reinforce regional growth and competitiveness among the regional authorities, municipalities, local action groups and enterprises. The next actor is Skellefteå, a municipality in Västerbotten region in the Northern part of Sweden (OECD 2021). The area has abundant natural resources that support various industrial activities, Northvolt battery factory is within this region (Jörgen 2022). Skellefteå plays an active role in developing a well-established strategy for the battery industry in Sweden; they are also one of the key investors in the emerging industry (*ibid.*). In addition, the municipality is

involved in the rapid development of different ancillary projects that support the sustainability of the battery industry, such as the construction of new housing units, schools, and leisure centres; these projects will attract and retain local and international labour force (Skelleftea.se 2021). The Kokkola Region Development Company (KOSEK 2022) also plays a similar role as VASEK in providing pro-bono services that support the growth and development of emerging businesses. Rana Utvikling is also a regional development company in the Nordland region of Norway that helps new businesses; the first lithium-battery cell production company, referred to as FREYR, is at Moi I Rana. There is a high concentration of energy companies in the region, also renowned for its vast capabilities in hydro-based electricity production (Rana Utvikling n.d.). Finally, MidtSkandia is a “Nordic border regional cooperation forum between Nordland’s county municipality with municipalities in Helgeland, Norway and the Västerbotten Region with municipalities in Sweden” (Regionvasterbotten.se). Its objective is to remove border barriers and contribute to an increased joint cross-border development project (*ibid.*). With the continuous growth of the battery industry cluster, an interesting observation is a high optimism among regional actors and stakeholders regarding the enormous potential and economic opportunities therein. These actors also share a sense of solidarity and commonality of purpose. Figure 2 below summarises some of the stakeholders’ perspectives on the importance of the battery industry and the NBB.



Fig. 2. The perspective of key stakeholders on battery production and the NBB.

Figure 2 shows the brief compilation of the opinions of some stakeholders that were expressed at different regional planning meetings consisting of the private and public actors, as shown above, and elaborated in the discussion section. Sand (2021a) notes that these opinions are mainly on the battery industry's expected contribution and the role of the NBB in fostering the sector. The opinion of the stakeholders suggests a high optimism and a positive synergy in their views regarding battery production in the region and the role of the NBB. In addition, they may have foreseen the numerous potentials and opportunities the emerging industry could bring to the region. For that reason, it can be said that this is a promising outlook for the future and a possible indication of the stakeholders' willingness and commitment to cooperate towards strengthening the battery cluster. Besides the identification of the medium- and long-term connectivity challenges that are expected to confront the battery industry, particularly with regards to the East to West links, the NBB has also made other recommendations that go beyond connectivity-related issues to other activities that can overall strengthen the growth and sustainability of the industry (Löfmarck *et al.* 2022). These include improving the visibility of the battery-producing potential and the regional economic opportunities in the international space through branding and public relations. In doing so, the region could attract more investors and skilled labour (*ibid.*). For instance, the appellation of the 'Nordic Battery Belt' draws attention to the geographical space (Nordic region) in which the battery industry is emerging. Previous studies have shown that branding is vital as it highlights a novel, innovative space for cooperation in a region (Wäckerlin *et al.* 2020). Empirical report has also suggested that there should be continued cooperation in knowledge co-creation within the NBB and across the public and private sectors, such as companies, universities, and the government, as this will strengthen the industry and the decarbonisation process (Löfmarck *et al.* 2022). The report also suggests the imperativeness of learning from other contexts on how to address the logistical loopholes through cooperation and improved data sharing. Finally, it notes that the battery industry is a capital-intensive project, hence, the need for governments of the constituting regions to continuously fund the work that is being done by the NBB towards improved infrastructural development and start-up financing and other energy-related ventures.

Making sense of the role and importance of the Nordic Battery Belt

Identification of the medium- and long-term logistical challenges

The findings reveal that the Nordic Battery Belt (NBB) is an EU collaborative enterprise funded by Interreg Botnia-Atlantica aimed at "developing a strategy for sustainable and cost-efficient cross-border logistics for the emerging battery cluster" (Kvarken.org 2021a, 2). The Nordic countries of Norway, Sweden, and Finland all have well-established transport infrastructure; however, empirical studies suggest that more transport infrastructure will still be needed to connect more areas within the region, as identified already (Löfmarck *et al.* 2022). On that account, this means that the pre-existing condition within the Nordic context before the emergence of the battery industry cluster is somewhat characterised by transport connectivity challenges, especially in the northern part of the region. The connectivity issues can be attributable to the elongated topography and vastly rocky terrain, making construction difficult (Sovacool *et al.* 2018). Over time, this has contributed to some of the connectivity challenges the emerging industry has to overcome. According to Aslani and colleagues (2013a), a more effective and efficient supply chain is required as renewable energy uptake increases.

Reiteratively, while the existing infrastructure in the region is adequate to support the battery cluster, it is expected that the industry will experience growth in a few years. As a result, thus there will be an increased need for transport infrastructure and connectivity that supports the supply value chain. The emerging battery industry is expected to face medium-and long-term connectivity challenges within the context in which it operates. Studies have shown that context-specific conditions influence the nature of a network formed (Fuchs & Hinderer 2014). Contextual factors also influence the kind of policy intervention adopted (Fornahl & Hassink 2017, 3). Consequently, the NBB was established in response to the contextual connectivity challenges with the aim of improving the supply value chain within the industry. The findings hence suggest that NBB's role as a regional network is to

proactively identify these potential challenges and develop logistical strategies and inventories that will facilitate the transportation of human and material resources within the battery cluster; because improved connectivity would ensure the removal of barriers to regional energy cooperation, increase the region's competitive advantage in the energy market, and reduce the industry's carbon footprints when the distances are shorter and well-connected.

The justification for establishing a regional network such as the NBB aligns with claims that energy transitions involve different actors (Coenen *et al.* 2021). This assertion hinges on the fact that the NBB is a deliberately designed structure, and its voluntary nature entails that the members of the network are not compelled or obligated in their actions by external forces, as already observed (Hoppe & Miedema 2020). In addition, "regional actors are better able to design successful policies than national actors due to their knowledge of place-specific conditions and ability to finetune policies" (Hansen & Coenen 2015, 97). Networks are thus designed to ensure the sustainability of clusters and their ability to renew themselves, thus preventing their decline (Fornahl & Hassink 2017). The establishment of the NBB will thus contribute to the sustainability of the battery cluster in the Nordic region. The chances and rate of achieving a sustainable battery cluster will depend on the level of commitment and cooperation among the actors in the NBB. Concerning this, empirical studies also reveal that "companies are not that interested in establishing formal structures in cooperating within the NBB" (Löfmarck *et al.* 2022, 51). Hence, the NBB remains a bottom-up approach to solving the identified logistical challenges, its effectiveness will still be to a large extent contingent on the degree of implementation of its strategies and recommendations by the regional and national authorities.

Fostering regional cooperation within the Nordic battery cluster

The battery cluster in the Nordic region will face similar connectivity challenges; that being the case, cooperation, and collaboration within the NBB in developing a common logistics strategy could benefit the battery cluster. This aligns with the claims that human factors such as collaboration and cooperation contribute to the energy transition process (Sovacool *et al.* 2020). The establishment of the NBB thus reinforces the claim that the energy transition process involves cross-jurisdictional and multi-actor participation (Hoppe & Miedema 2020). Nordic cooperation will be beneficial in solving the identified "East-West transport infrastructure connectivity challenges existing in all the Nordic countries" (Löfmarck *et al.* 2022, 53). According to Cleophas and colleagues (2019) and Gatta and others (2019) collaboration among actors remains one of the keyways to achieving sustainable and cost-effective logistics. The NBB will thus provide the space for cooperation where the constituting actors will leverage their diverse economic expertise, business acumen and finance experiences to develop the needed logistical strategies. The emergence of the NBB thus entails that science and technology are not the only drivers of the energy transition; regional actors also shape and influence transitions through cooperative and collaborative interactions such as the exchange of knowledge and resources (Lutz *et al.* 2017; Hess & Sovacool 2020; Coenen *et al.* 2021). This cooperation implies that the region could leverage the common opportunities geared towards reducing carbon-based energy dependency and increasing renewable energy production and distribution (Aslani *et al.* 2013b; Hongisto & Tukiainen 2020).

Clusters are not closed entities but are embedded in an ecosystem of actors, linkages, and rules (Fornahl & Hassink 2017, 3). The Nordic battery cluster comprises different unique and related companies that will face similar transport connectivity challenges in its supply value chain. Hence, cooperation via the NBB embedded in the Nordic context, where the battery industry is domicile, plays an imperative role and will likely positively impact the battery cluster within the broader energy ecosystem. As stated earlier, cooperation between the Nordic countries is strong due to the historical antecedents, similarity of contexts and path dependence (Tallqvist *et al.* 2019). In this regard, cooperation among actors in the NBB will probably be seamless due to the region's close historical ties and evolution.

Another important point is that the growth of the battery industry and the consequent emergence of the NBB is reconfiguring and deepening Nordic cooperation. For instance, although the Kvarken region is historically comprised of areas in Finland and Sweden, such as the Ostrobothnia, Southern Ostrobothnia, Central Ostrobothnia, County of Västerbotten and the municipality of Örnsköldsvik in

Sweden (Kvarken.org 2021c). The establishment of the NBB has now extended the existing cooperation within the Kvarken region also to include the Nordland region of Norway. Accordingly, proximity and the similarity of contextual factors facilitate regional collaboration and the growth of the battery cluster.

Complimenting the efforts of stakeholders in the Nordic Battery Cluster

With the growth of the battery industry, regional cooperation involving key stakeholders will become increasingly important and the Nordic battery cluster will be driven not only by the NBB but also by other key stakeholder both within the public and the private sectors. As shown in Table 2, the stakeholders are one of the main actors that will play critical roles alongside the NBB in ensuring a thriving battery cluster in the region. As already mentioned, clusters contribute to a region's development and networks, actors and institutions are among the drivers of a cluster development (Fornahl & Hassink 2017, 2). The aim for establishing the NBB strongly reinforce the suggestions of other stakeholders and this synergy will likely present a strong and harmonized policy goal. For instance, Table 2 suggests that some stakeholders are already advocating for a joint regional labour strategy, such as establishing a new labour market and joint infrastructural development to strengthen cooperation in the internal energy market (Sand 2021b).

The stakeholders' views indicate high optimism about the prospects of the battery industry, and such high confidence may hinge on the historical successes achieved through cooperation within the region, as suggested by (Aula *et al.* 2020). The stakeholders' perception also suggests their active involvement in the exchange of ideas that could strengthen and contribute to the sustainability of the emerging battery cluster. Furthermore, the positive perception expressed in Table 2 by the stakeholders seems to be in harmony or synergy with each other; also, their commitment to actively participate in fostering the growth of the industry suggests that they expect a positive contribution from the industry in terms of job creation, infrastructural development, and revenue. The disposition of the stakeholder towards the sector could be because of the win-win situation for all who are involved in the emerging industry. Furthermore, they emphasised positive economic externalities from the industry; however, this is not to say that the industry may not pose some environmental challenges, but now, it seems the focus of the stakeholders is on how to get the initiative started while also taking cognisance of the potential sustainability issues that may arise in the process.

The harmony between stakeholders' opinions also suggests that these key players have a commonality of purpose, which could be essential in influencing the transition process and in achieving the predetermined decarbonisation objectives. While cooperation plays a pertinent role in regional energy transitions, it is necessary to note that different factors can influence cooperation, such as the interests, goals, and actions of actors within a network (Hoppe & Miedema 2020). Although on one hand the actors from the three constituting regions have similar interests to ensure the growth and sustainability of the battery cluster through improved infrastructure connectivity. On the other hand, while cooperating, regions could sometimes also harbour individual interests, and this could manifest through unhealthy competition in terms of having a slight edge over others and this could be a potential grey area. Studies on Nordic Cooperation have also pointed towards the tendency of an individual country's interest encroaching on Nordic cooperation (Aula *et al.* 2020). Consequently, how effective the NBB turns out will also depend on the level of trust in the form and the level of competition therein.

The way forward: leveraging on the unique Nordic context via the NBB

The regional level is renowned for its innovation policies supporting new cluster and its potential diffusion (Fornahl & Hassink 2017). Regional innovation policies should be place-based or context specific to avoid the over-standardisation syndrome or misapplication of innovative strategies, that is, the one-size-fits-all approach (*ibid.*,1). Furthermore, studies suggest that actors and the network within proximity are characterised mainly by similar economic contexts such as raw materials and well-established infrastructure (Lutz *et al.* 2017; Hongisto & Tukiainen 2020). As observed earlier, the battery industry is emerging in the Nordic region with similar contexts, consequently, the cluster is also expected to face similar connectivity challenges. Thus, the actors within the NBB must continue

to leverage the shared similarities to their advantage. For example, the geographical proximity of the Nordic countries could facilitate the realisation of sustainable and cost-effective transport connectivity within the Nordic battery cluster.

The regional actors within the NBB could also continuously leverage other regional shared characteristics towards consolidating cooperation. For instance, the similar operational knowledge base of regional development agencies that constitute the NBB in areas such as business strategy and economic development. These agencies provide favourable conditions for businesses to thrive via pro-bono services for business development, particularly for start-ups. Proximity increases the synergy among network actors and the chances of realising a sustainable and cost-effective transport system that fosters regional economic development. Networks cooperate through information and knowledge sharing (Lutz *et al.* 2017). Hence, there is a need for continued and increased dissemination of information regarding the emerging battery industry among the public, the academic community, and potential investors (Löfmarck *et al.* 2022). Cooperation within the NBB therefore needs to continue because of its vital role in providing the opportunity for the exchange of ideas and resources in developing the region's logistical strategies. Finally, the solid historical ties that is inherent in Nordic cooperation could serve as a morale booster, an added advantage and a reassuring factor that should be continuously leverage towards a sustainable industrial cluster.

Based on the adoption of Hoppe and Miedema (2020, 6) conceptualisation of network in this paper, the most likely weakness of the NBB will be due to its voluntary nature characterised by informal attributes which, to a large extent, lacks the jurisdiction or the requisite authority to implement its logistical strategies that were developed. Consequently, their contributions could likely be undermined by low compliance from national governments who not only have the wherewithal to translate policy strategies into action but are also known for enacting legislation that is 'border-blind' (Interreg 2022). Hence, such impediments from the central government could manifest through bureaucratic delays or red-tapism in implementing cross-border transport strategies. Overall, this study only provided an overview of the NBB; future research could augment this study by eliciting feedback through semi-structured interviews from actors in the NBB on how it will ensure the full implementation of its strategies within the region.

Conclusions

There is no doubt that batteries support the decarbonisation process, and as a result, there is an increasing demand for them. Consequently, there is an emerging battery cluster in the Nordic region of Norway, Sweden, and Finland, which will contribute to meeting this rising demand by utilising its available local natural resources for battery production. As the industry begins experiencing growth, it is expected that there will be medium- and long-term transport connectivity challenges in the supply value chain. That been the case, it is imperative to ascertain the role of networks' towards solving the infrastructural challenges – an aspect in regional energy transitions literature that is currently underexplored. The paper examined the Nordic Battery Belt (NBB), regarded as a regional network established to develop logistical strategies for solving the connectivity challenges in the Nordic region. The network perspective enhanced the understanding of the role of the NBB in the emerging Nordic battery cluster. From the results, the main driving factor for establishing the NBB is the contextual (infrastructural) conditions within the Nordic region, which also poses a challenge to the sustainability of the battery cluster. Thus, the establishment of the NBB is to facilitate cooperation towards strengthening the supply value chain within the cluster. The NBB not only identifies the medium- and long-term logistical challenges, but also fosters regional cooperation within the battery cluster, as well as compliments the efforts of stakeholders in the battery industry in the region. It is also interesting that stakeholders see massive potential in battery production and are keen on cooperating towards an accelerated regional energy transition. Empirically, this paper increased the understanding of the connectivity challenges in the Nordic context that may impede an accelerated decarbonisation process; theoretically, it increases the knowledge on the role of network (NBB) in regional energy transitions. The researcher thinks the paper could be further strengthened methodologically by collecting primary data from stakeholders in the battery industry via semi-structured interviews.

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