

# Risks in transition – the case of Northvolt and Skellefteå

EDGAR KNIGHT 2023  
MVEM31 MASTER'S THESIS FOR 30 CREDITS  
ENVIRONMENTAL SCIENCE | LUNDS UNIVERSITY



# Risks in transition – the case of Northvolt and Skellefteå

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2023



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Lund 2023



# Abstract

This paper explores how barriers and risks are perceived by different actors involved in Northvolt's establishment in Skellefteå, Sweden, through the Multi-Level Perspective (MLP) and risk perspective. The study employs a qualitative research design and utilizes document analysis and semi-structured interviews to collect data. The findings contribute to the existing risk framework by introducing two additional categories of risks and barriers present in northern Sweden's transition and examine how these barriers and risks interact. The analysis extends the MLP by providing new insights into the roles of different stakeholders and the complex nature of socio-technical transitions. Key findings highlight the critical role of government in addressing infrastructure needs, bridging competence gaps, and fostering technological innovation. The paper proposes policy and strategic recommendations for future large-scale industrial establishments. This research offers valuable insights for policymakers involved in socio-technical transitions and suggests directions for future research to understand further and manage these transitions.



# Popularärvetenskaplig sammanfattning

Denna studie undersöker övergången till en hållbar framtid genom att fokusera på den framväxande batteriindustrin i Sverige, med särskild fokus på Northvolt och deras etablering i Skellefteå. Målet med studien är att förstå de hinder och risker som upplevs av olika aktörer inom både den offentliga och privata sektorn, och hur dessa hanteras. Sverige har satt ett ambitiöst mål att nå nettonollutsläpp av växthusgaser till år 2045. En central del i denna övergång är elektrifiering, där tillgången till batterier är avgörande för energilagring och användning i elfordon. Northvolt, ett svenskt batteriföretag grundat 2015, valde Skellefteå som plats för sin första fabrik 2017 på grund av tillgången till billig och grön energi. Denna etablering markerar starten på vad som har beskrivits som en industriell revolution i norra Sverige, vilket har lett till stora investeringar och en förväntad befolkningstillväxt i regionen.

Studien ställer två huvudfrågor: "hur uppfattar Northvolt och andra aktörer på olika styrningsnivåer risker kopplade till övergången?" samt "vilka strategier, policys och åtgärder används för att hantera dessa risker?". Studien använder en kvalitativ forskningsdesign som innefattar dokumentanalys och semistrukturerade intervjuer. Inom ramarna för dokumentanalysen granskas officiella rapporter och policydokument, medan intervjuerna ger djupare insikter i deltagarnas personliga attityder och policyimplementeringar. Genom att kombinera dessa metoder kan studien ge en bredare bild av de upplevda riskerna och strategierna. Resultaten visar att både Northvolt och Skellefteå kommun står inför flera hinder och risker. De risker och hinder som har identifierats är relaterade till hållbarhet, lagstiftning, koordinering, infrastruktur, marknad samt teknologisk utveckling. För att hantera dessa risker har olika strategier implementerats, såsom ekonomiska incitament, etablering av kunskapscentrum, och satsningar på återvinning av batterier.

Studien belyser vikten av att förstå den komplexa dynamiken mellan de olika aktörerna, riskerna och deras roll i övergången till en hållbar framtid. Det framgår att övergången inte följer en linjär process utan är beroende av både interna och externa faktorer som påverkar hur snabbt och effektivt förändringar kan genomföras. Beslutsfattare och industriledare måste vara anpassningsbara för att hantera dessa dynamiska utmaningar. Genom att undersöka hur olika aktörer uppfattar och hanterar risker kopplade till övergången till en hållbar batteriindustri, bidrar denna studie till en djupare förståelse av de hinder och möjligheter som finns på vägen mot en hållbar framtid. Det framgår tydligt att en samordnad insats från både offentliga och privata aktörer är nödvändig för att lyckas med denna omställning.





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# 1. Introduction

This chapter begins by providing an overview of the problem area. It then examines the existing body of research and identifies critical gaps that the study aims to address. The chapter outlines the specific aims and research questions that guide the investigation and outlines the scope and delimitations of the study.

## 1.1. Background

Swedish industries currently account for around one-third of Sweden's territorial emissions. To reach net zero by 2045, new technologies and solutions are required. Electrification is a crucial strategy for this transition to net zero (Energimyndigheten, 2023a). Specifically, access to batteries is an essential part of electrification to succeed, as they are necessary for energy storage (Energimyndigheten, 2023a). The establishment of battery manufacturing as an industry, one that is said to soon become a new 'basic industry,' alongside wood and steel-making (Energimyndigheten, 2023e), has also marked a shift in the automotive industry as it transitions to electric vehicles (EVs) (Näringsdepartementet, 2022, p. 7).

In 2015, the Swedish company Northvolt was established. In 2017, Skellefteå was chosen as the location for their first factory due to the access to cheap and green energy (Sveriges Kommuner och Regioner, 2023, p. 8). The establishment of Northvolt in Skellefteå is called the starting shot of an unprecedented 'industrial revolution' taking place in northern Sweden – one that has come about due to a massive influx of investments that approximate 1100 BSEK (billion Swedish Kronor) (Näringsdepartementet, 2022, pp. 5-6). The establishment of Northvolt in Skellefteå also marks the beginning of a reversal in population decline and stagnation trends. From 1990 until 2010, the population in Skellefteå declined by around 5000, followed by several years of stagnation (Sveriges Kommuner och Regioner, 2023, p. 9). However, due to recent developments, it has started growing again, and Skellefteå's population is projected to increase from 74,700 to 90,000 by 2030 (p. 9).

Northvolt relies on mining outside of Europe to meet its needs, raising concerns about potential environmental and human rights violations (Business Sweden, 2023, p. 52). Simultaneously, global developments are increasing demand as more countries

electrify and transition to EVs. The growing demand for raw materials reflects a global trend of heightening competition for materials and competencies. Considering the increasing demand for raw materials, a stakeholder in the Nordic battery industry pondering on the European dependence on third parties for raw materials questioned, "Where might they sell?" suggesting that countries with domestic access to raw materials may prioritize their own needs. (p. 54).

As Sweden pushes towards its 2045 net-zero goal, the emerging battery industry and regions like Skellefteå face significant challenges. These challenges include securing sustainable and ethical sources of raw materials, addressing the skills shortage, the stresses of intense population growth, and navigating global market developments. Understanding and mitigating these risks will be essential for Sweden's battery industry's continued growth and success.

## 1.2. Existing research and knowledge gaps

Numerous studies have explored the role of the state and industry in technological transitions and the decarbonization of industry (Johnstone & Newell, 2018; Nilsson et al., 2021; Panetti et al., 2018; Svensson et al., 2020; Khan et al., 2021; Hildingsson et al., 2019). Existing literature underscores the necessity of substantial resource infusion and effective coordination between state and market actors to develop emerging technologies (Johansson et al., 2021; Hildingsson et al., 2019). Notably, most of these studies focus on decarbonizing energy-intensive industries, particularly the steel sector. The Multi-Level Perspective (MLP) is a framework that analyzes transitions by looking at the interactions between actors on three levels: niche innovations, the socio-technical regime, and the landscape (Geels, 2019). Previous literature has applied this framework to examine the speed of transitions (Sovacool, 2016; Andersen & Geels, 2023), the role of various actors (Fischer & Newig, 2016), and their interactions (Driel & Schot, 2005; Anderson & Geels, 2023). There is a noticeable gap in the literature concerning the role of the Swedish battery industry in the transition to net zero, particularly as the MLP has yet to be applied to a case study of a company in this sector.

The paper also fills a gap in the risk perspective literature. While previous studies have been done on the risks facing industries in sustainability transitions (Löfgren & Rootzén, 2021; Kitzing et al., 2020; Johansson et al., 2021), they primarily adopt a firm perspective. This paper extends the risk perspective by incorporating the viewpoint of a local stakeholder, specifically Skellefteå municipality. The paper further expands our understanding of risk by integrating an MLP into its analysis, thus providing a temporal and social dimension to the study of risk. This approach enriches the risk perspective by considering both the chronological and societal contexts in which transitions occur. In sum, this paper seeks to contribute to the existing body of knowledge on socio-technical transitions and fill a critical gap by examining actors'

perceived risks. By investigating the perceptions and strategies employed to address barriers and risks, the study aspires to generate novel insights beyond the current scope of literature, thereby enhancing our understanding of the intricate dynamics involved in socio-technical transitions.

### 1.3. Aims and research questions

The paper explores how actors in the public and private sectors perceive and address barriers and risks related to the establishment and expansion of Northvolt, a company in the battery industry. Informed by literature on barriers, risk, and transitory failures (Johansson et al., 2021; Löfgren & Rootzén, 2021), the paper seeks to explore how risk is perceived by actors at various levels of governance (state-level, state agencies, and Skellefteå), and by Northvolt. Furthermore, the paper aims to see what strategies, policies, and actions have been taken or proposed as necessary to address barriers and risks. The paper employs the MLP to understand the interactions between niche innovations, socio-technical regimes, and the landscape in the context of the Swedish battery industry, providing insights into the interactions between actors in the broader context of sustainability transitions.

This paper expands on the literature in two primary ways. Firstly, looking at several actors involved in the transition in northern Sweden allows for a more holistic picture of what barriers and risks exist. Secondly, the paper contributes to our understanding of the characteristics of transitions. The author hopes the paper will expand current knowledge and understanding of the role of risk mitigation strategies in technological transitions. Hence, the research questions are formulated as:

- *What risks and barriers are perceived by Northvolt and other actors at various levels of governance?*
- *What strategies, policies, and actions address the barriers and risks associated with the transition?*

### 1.4. Scope and delimitations

The study focuses on the Swedish battery industry, specifically highlighting Northvolt, the municipality of Skellefteå, the Swedish government, and relevant state agencies such as the Energimyndigheten (the Swedish Energy Agency) and Tillväxtverket (the

Swedish Agency for Economic and Regional Growth). These actors were chosen as they represent a comprehensive set of stakeholders in the battery industry. Although relevant to the Swedish battery industry, Naturvårdsverket (the Swedish Environmental Protection Agency) was not included in this study for two reasons. Firstly, the information obtained from document analysis did not provide new insights beyond what was already gathered from other sources. Secondly, the study already considered the Industrial Leap program, which serves a function similar to Naturvårdsverket's Klimatkivet. Therefore, the other parties included adequately covered the contributions and roles of relevant stakeholders. The study encompasses Northvolts establishment in 2017 to the present day. The deliberate focus on Sweden is justified by its significant advancements in the battery sector. By focusing on Swedish actors, the study aims to provide a detailed understanding of the local dynamics and challenges relevant to Sweden's transition. International perspectives are only considered to the extent that they impact the Swedish context. This focus ensures that any findings apply directly to the Swedish context, offering insights for policymakers and other stakeholders involved in the transition.

## 2. Theoretical framework

This chapter introduces the frameworks that underpin this study.

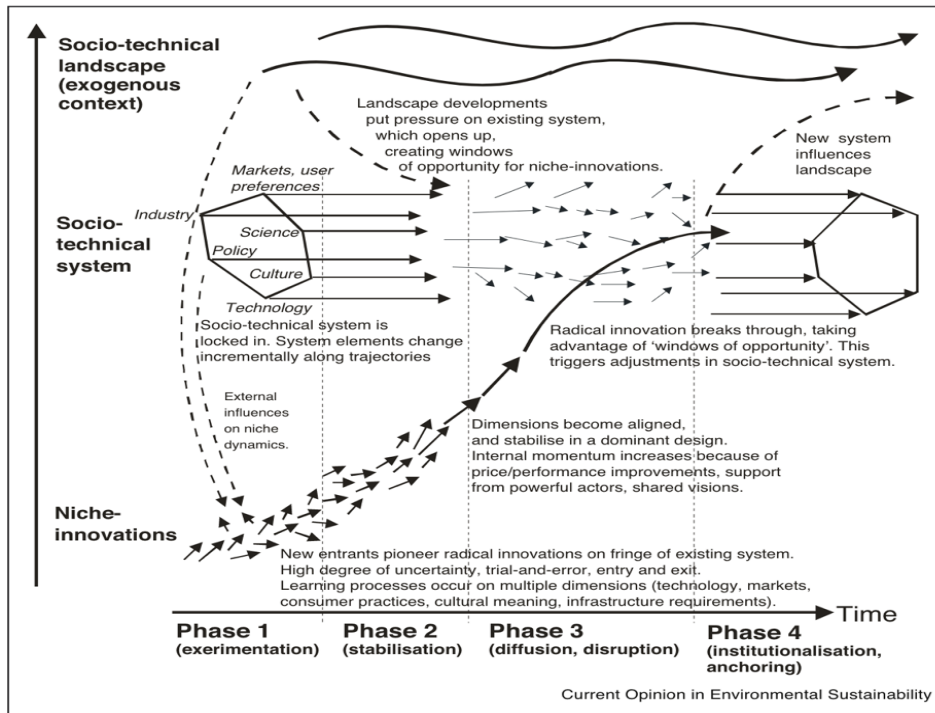
### 2.1. Multi-level perspective

#### *Levels and interactions of transition actors*

This paper uses the MLP, a widely used perspective in research on socio-technical transitions. Within transition studies, socio-technical systems are defined as the arrangement of various actors, rules, and technologies that fulfill a particular societal function (Kanger, 2021, p. 2). The MLP differentiates between three analytical levels within the socio-technical system (Kanger, 2021): niches, socio-technical regimes, and socio-technical landscapes (Andersen & Geels, 2023; Geels, 2018; Johnstone & Newell, 2018). The MLP focuses on the interactions between niches, i.e., protected spaces where new and emerging technologies and innovations are developed (Johnstone & Newell, 2018), and regimes, which are defined by a shared set of rules and institutions of a particular system that dictates the actions of the actors within it (Kanger, 2021, p.2). Niches and regimes are ‘surrounded,’ and their dynamics are impacted by the landscape, representing exogenous forces and structural factors such as wars, climate change, or demographic change (Kanger, 2021, p. 2).

According to Geels and Schot (2007, p. 400), the transition process involves niches gaining momentum, landscape-level changes creating pressure on the existing regime, and the destabilization of the current regime, providing a window of opportunity for niche innovations (see Figure 1).

Figure 1. Multi-level perspective on socio-technical transitions.<sup>1</sup>



Geels and Schot (p. 402) emphasize the similarities of niches and socio-technical regimes in that they both have the characteristics of a community of interacting groups; the difference is that for socio-technical regimes, the communities are “large and stable, while for niches, they are small and unstable.” Moreover, the rules by which niches and regimes coordinate action differ, “for regimes, these rules are stable and well-articulated; for niche innovations, they are unstable and ‘in the making’” (p. 402). Geels and Schot (p. 403) identify three kinds of rules: regulative rules consist of regulations, standards, and laws; normative rules comprise relationships, values, and behavioral norms; *cognitive rules* include belief systems, innovation agendas, problem definitions, guiding principles, and search heuristics.

<sup>1</sup> From “Socio-technical transitions to sustainability: A review of criticisms and elaborations of the Multi-Level Perspective” by F. W. Geels, 2019, *Current Opinion in Environmental Sustainability*, 39, p. 191 (<https://doi.org/10.1016/j.cosust.2019.06.009>). Copyright 2019 by Elsevier.



### *Phases of transition*

To put socio-technical transitions into perspective, Patt (2019, pp. 154-156) summarizes the transition from horses to cars for urban transportation. This transition took place between 1890 and 1930 and illustrates how the invention of the car did not lead to instantaneous market dominance. Instead, the simultaneous changes to the landscape and socio-technical regimes at the time facilitated the possibility of a transition. At the landscape level, the societal transition, namely the rise of cities and suburbs, increased the need to commute longer distances to work. The introduction and the popularity of the tram and the bicycle caused governments to develop traffic laws, and the bicycle wheels required changes to the physical aspects of the road surface; it had to be made smoother for smooth riding (p. 155). Roads stopped being public walkways, but rather vehicle lanes—sidewalks had to be added. The first cars were either electric or based on steam power, which had been around for a long time and was cheap to produce. In this transition, the technological change, or ‘niche innovation,’ was the gasoline-powered racecar, at the time, a new technology that was expensive to produce. In time, the gasoline car became cheaper to produce than the steam-powered car, pushing both the steam-powered car and horses aside as the primary form of transportation.

Geels (2019, p. 190) suggests that transitions occur over several years or decades and can be divided into four phases (see Figure 1). Recent transitions have, however, occurred faster than transitions of the past (Sovacool, 2016), which has contributed to the discussion on whether transitions can occur faster “if they are consciously governed, [when] most historical transitions were emergent, market-driven processes” (Kern and Rogge, 2016 as cited in Edmondson et al. 2019, p. 2). Edmondson et al. (p. 12) suggest a policy mix that considers the timing of specific policies relative to the transition phase. These include the promotion of positive feedbacks, and the reduction of negative feedbacks for the ‘niche’ until it has matured enough to become the new dominant socio-technical configuration, while gradually phasing out support for the old dominant socio-technical regime. This suggests a top-down approach to transitions. Fischer and Newig (2016, p. 14) suggest that the state can act as a “leading or supporting actor” by organizing resources and establishing markets for sustainable innovation, while regional actors have “weak agency” as they do not have the capacities legally enforce action, and their administrative capacity is limited.

### *Interaction between niche and regime*

Geels (2018, pp. 86-87) argues that a drawback in many studies is that niche-focused studies conceptualize transitions “as a singular disruptive process with new technologies as a driving force,” failing to address broader systematic transformations

inherent to the transition process. Geels (p. 87) suggests that how we think about system transitions should change. Instead of viewing them as sudden, disruptive breakthroughs driven primarily by innovations, transitions are better understood as reconfigurations that result from the adoption of niche innovations within existing regimes, as well as through “incremental regime improvements, changes in the relative size of regimes, or new combinations between niche and regime elements.” Geels (p. 88) suggests that niche innovations impact system reconfigurations through three interactions between the niche and regime. *Competition*, such as that between steam-powered and gasoline cars, can shift the scales of the sociotechnical systems. In the case of the horse versus the gasoline car, this shift can replace the previous regime. *Symbiosis* between niches and regimes characterizes the positive interactions between systems. Geels (p. 88) highlights that “a shift towards [EVs], for instance, would create symbiotic linkages between electricity and auto-mobility regimes.” Finally, *integration* characterizes the interaction of niches and regimes to form a new system. Geels (p. 88) states that integrating buses, trains, and cycling regimes could be a transition “into inter-modal transport systems with linked schedules, easy transfer, and integrated payment systems.” The symbiosis and integration type of interactions suggest socio-technical regimes, and the companies within them can play an active part in sustainability transitions. Geels (2019, p. 194) suggests that incumbent firms that may be locked into existing regimes may reorient towards “green niche innovations” if they see emerging economic opportunities.

## 2.2. Risk analysis

This paper builds its framework mainly from Löfgren and Rootzén (2021) and their four categories of barriers and risks and is aided by Johansson et al. (2021) and Kitzing et al. (2020).<sup>2</sup> Löfgren and Rootzén (2021) introduce a conceptual framework that addresses market, regulation, technology, and coordination barriers. Johansson et al. (2021) provide a conceptual framework highlighting risks related to markets and technological investments. Kitzing et al. (2020) offer a temporal and systems perspective on transition risks.

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<sup>2</sup> This paper defines barriers as obstacles to transitions and risks as the possibility of adverse outcomes stemming from actions or external effects. Risks may also include actions taken to achieve a specific goal when the result of said goal being positive is uncertain.

### *Market barriers and risks*

There are several market risks related to technological development. While companies are increasingly required to internalize carbon costs, actors who attempt to introduce or develop new technologies with higher production costs still face significant market risks. Johansson et al. (2021, p. 1) suggest that competition from existing technologies, which are often cheaper to produce (and usually readily available), is a barrier for emergent technologies as long as consumers are unwilling to pay a premium for the new technology. In this sense, market risk relates to human behavior – the risk that exists is based on whether or not consumers will be able or willing to pay the product's price proportionate to the cost of producing it. Furthermore, the long planning horizons and lead times often associated with construction, obtaining permits, and technological development increase the risk of exposure to external market changes (Löfgren & Rootzén, 2021, p. 193). Kitzing et al. (2020, p. 374) argue that risk is complex for investors to assess adequately in the early stages of technology development and that the risks may even be perceived as higher than what “a purely objective risk assessment would suggest.” Kitzing et al. (p. 374) continue to posit that risk-reducing policies can enhance participation, i.e., the will for investors to participate, by giving a “comforting signal” when “risk assessment of new technologies [are] still in the learning phase.” Kitzing et al. (p. 379) argue that this can be accomplished by various economic instruments, which can be advantageous in the early phase of niche technology development.

### *Technology barriers and risks*

Technological risks encompass the uncertainties of developing, deploying, or scaling up new technologies. Johansson et al. (2021) discuss technological investment risk as referring to the uncertainties surrounding developing or deploying new technology, emphasizing that a product's potential market demand does not ensure its development or implementation. This is due to the need for new technologies to “demonstrate feasibility, technical performance” alongside its commercial viability (Löfgren & Rootzén, 2021, p. 193). Löfgren and Rootzén mention nonstandard design and the “high level of system integration” as risks linked to developing new technologies (p. 193). A further issue in technological investment risk is the problem of collective action among producers. Johansson et al. (2021) note that it is often impractical for a single investor to develop a technology single-handedly, create the required infrastructure, and scale production due to the prohibitive costs or the risk of failure.

### *Regulatory barriers and risks*

Löfgren and Rootzén (2021) identify barriers and risks associated with the regulatory environment, including uncertainties related to climate policy changes and the design and outcome of policy instruments. Löfgren and Rootzén (p. 194) emphasize that the lack of global and national climate policy agreements hinders business case development for investments in new technologies in the basic material industry. Furthermore, uncertainties may exist regarding the commitment and endurance to climate policy and innovation support (p. 194). National or regional laws may also impact firms; if companies are regulated more stringently in one area over another, the companies settled in that region “are at a competitive disadvantage as compared to companies in a less stringent jurisdiction” (p. 194). Another source of risk is the “lengthy permitting processes and a lack of long-term clarity with respect to [...] mining rights” (p. 194). Kitzing et al. (2020, p. 337) further emphasize rapid or unanticipated changes to policies or instruments as potential sources of regulatory risks. Moreover, Kitzing et al. (p. 379) highlight the importance of adaptability and argue that keeping a narrow financial view of risk when selecting regulatory instruments (such as subsidies or taxes) disregards complex risks that affect the entire system (such as social, technological, and environmental factors).

### *Coordination barriers and risks*

Coordination barriers highlight the necessity for the timely deployment of support infrastructure and aligning efforts across the supply chain. The successful deployment of new technologies requires the parallel planning and deployment of complementary infrastructures, cross-supply chain collaboration, and international coordination. Furthermore, Löfgren and Rootzén (2021, p. 195) suggest that as technological and societal priorities shift, there is a parallel need for business groups, labor unions, and government entities to adapt their frameworks and focus as these organizations reflect and support the structural systems of existing technologies. Johansson et al. (2021, p. 4) emphasize the collective action problem as a source of coordination risk. This refers to the risk that necessary investments, which are not directly under a single company’s control, are not made in a timely or coordinated manner. This lack of coordination could potentially influence the broader impact of the technology or the advancement of the industry. Kitzing et al. (2020, p. 378) support this view by arguing that technology is embedded in a “larger socio-technical system,” where mutually influencing effects influence long-term consequences and current technology costs. Therefore, technological change in a sustainable transition involves changes beyond introducing a new technology. By extension, risks need to be handled beyond the scope of securing the successful development of a specific technology. In parallel with

technological developments, adaptations, and transformations may have to occur among suppliers (as in more sustainable raw materials extraction for batteries), complementary industries or support infrastructures may have to be developed (i.e., charging stations are a support infrastructure that is important for successful EV adoption), as well as competence development, both among the existing workforce, but also the acquisition of new expertise.



## 3. Method

The following chapter outlines the research design and methods employed in this paper. Finally, it reflects on ethical considerations that were taken into account during the research.

### 3.1. Research design

This paper employs a qualitative research design utilizing document analysis and semi-structured interviews. Drawing on the methodology outlined by Bryman and Bell (2019), content analysis is utilized in document categorization and analysis. This approach is beneficial for this research, as it allows for the systematic examination of written documents and interview transcripts. (p. 272). Document analysis was chosen since it allows for the evaluation of official records and documents without the need for direct participation from actors who might be reluctant to be interviewed. This method is appropriate considering the first research question regarding the perceptions of barriers and risks, as documents provide a non-reactive and unobtrusive method to assess official stances regarding barriers, risks, and mitigating strategies (p. 273).

Semi-structured interviews are used in this research design to allow for deeper insights than what documents can provide, offering insights into personal attitudes toward risks and the nuances of policy implementation. It allows for the interaction with representatives of key stakeholders in the transition and allows for personal interpretations and experiences, which may not be evident in official documents; they also allow for the exploration of perceptions of risks and in what context these perceptions are formed. The interviews also validate findings from the document analysis, enhancing the findings' reliability.

As Bryman and Bell (p. 284) outlined, a coding manual is a crucial part of content analysis as “it provides a complete listing of all categories for each dimension to be coded, as well as guidance on how to interpret the dimensions.” Therefore, creating the coding manual was a crucial aspect of the process. Thus, a coding manual was designed to highlight themes related to barriers, risks, and mitigation strategies. The research design is deductive as the research questions are based on the framework by Löfgren and Rootzén (2021), which guided the data collection process. Deductive

research involves starting from a theoretical framework and then collecting data to test that framework (Bryman and Bell, 2019, p. 7). Using the framework by Löfgren and Rootzén (2021) ensured the data collection was systematic and grounded in established theoretical constructs.

## 3.2. Data collection

### *Document analysis*

The documents were selected based on their relevance to the research topic and downloaded from the respective actors' websites. When access to relevant documents from a specific actor was limited, documents from 'outside' actors (i.e., actors not included in the study) were used. An example is the report from Näringsdepartamentet (2022), a report commissioned by the government on the transition in northern Sweden, and in the case of Skellefteå, a report from Sveriges Kommuner och Regioner (SKR, 2023) on the risks taken on by municipalities in the green transition was used for additional information. See Table 1 below for a complete list of analyzed documents.



Table 1. A complete list of documents used in document analysis.

Actor	Title
Northvolt	<ul style="list-style-type: none"> <li>• Northvolt (2021). <i>Sustainability report 2021</i></li> <li>• Northvolt (2022a). <i>Enabling the future of energy sustainability and annual report 2022</i></li> <li>• Northvolt (2022b). <i>TFCD report</i></li> </ul>
Government	<ul style="list-style-type: none"> <li>• Näringsdepartamentet (2022). <i>Rapport från samordnaren</i></li> <li>• Regeringen (2022). <i>Regeringens proposition 2022/23:1</i></li> <li>• Regeringen (2023). <i>Regeringens klimathandlingsplan - hela vägen till nettonoll</i></li> </ul>
Tillväxtverket	<ul style="list-style-type: none"> <li>• Tillväxtverket (2022). <i>Gröna industrisatsningar i norra Sverige</i></li> <li>• Tillväxtverket (2023a). <i>Från forskning till konkurrenskraft</i></li> <li>• Tillväxtverket (2023b). <i>Tillväxtverkets årsredovisning 2023</i></li> </ul>
Energimyndigheten	<ul style="list-style-type: none"> <li>• Energimyndigheten (2020). <i>Accelerate energy transition for a sustainable society</i></li> <li>• Energimyndigheten (2023a). <i>Energimyndighetens årsredovisning 2023</i></li> <li>• Energimyndigheten (2023b). <i>Fortsatt samverkan kring Sveriges delar av en hållbar europeisk batterivärdekedja</i></li> <li>• Energimyndigheten (2023c). <i>Strategic priorities in energy research and innovation</i></li> <li>• Energimyndigheten (2023d). <i>Kompetensförsörjning för elektrifiering</i></li> <li>• Energimyndigheten (2024). <i>Industrins energi- och klimatomställning</i></li> <li>• Svenska Dagbladet (2023). <i>Trots 100 miljarder – Northvolt ”inte i hamn”</i></li> </ul>
Skellefteå	<ul style="list-style-type: none"> <li>• Skellefteå (2022). <i>Skellefteå 2030 Strategy for Sustainable Social Transformation</i></li> <li>• Skellefteå (2023a). <i>Skellefteå kommuns Årsredovisning 2022</i></li> <li>• Skellefteå (2023b). <i>Delårsrapport 2023</i></li> <li>• Sveriges Kommuner och Regioner (2023). <i>Vem ska stå för risken?</i></li> </ul>

The chosen documents have undergone the four criteria for assessing their quality outlined by Scott (1990, p. 6) in Bryman and Bell (2019, p. 273). The four criteria involve assessing the documents by their authenticity (making sure the documents are genuine and of unquestionable origin), credibility (the documents are free from error and distortion), representativeness (the documents are typical of what they are supposed to represent) and meaning (the documents are clear and comprehensible).

### *Semi-structured interview*

The interviews were designed based on Kvale's (2014) seven-stage process, which includes thematization, designing, interviewing, transcribing, analyzing, verifying, and reporting (Kvale, p. 102). The interview design structure and approach were loosely based on these steps.

The first step encompassed figuring out *what* and *why* of what was being researched. Due to the nature of the research, this process included reading various academic papers and websites for multiple actors such as Skellefteå municipality, Northvolt, the Swedish government, Energimyndigheten, and Tillväxtverket. This step was followed by writing the interview questions, which acted as conversation starters, allowing the interviewees to discuss their areas of expertise freely. Designing the interviews in this way allowed for one question to naturally lead to several interesting, related topics and viewpoints that might not have been considered before the interview. Due to the different roles of the stakeholders interviewed, the contents of the prepared interview questions varied. On average, each interview guide consisted of around ten questions. The interviews were scheduled to last between 45 minutes and one hour. The next step was the transcription of the interviews. Relevant sentences or conversations were entered into a coding schedule from the transcriptions. The interviews were transcribed from Swedish to English using the DeepL translation software, which was chosen for its precise translations and capability to capture linguistic nuances. Subsequently, the transcripts underwent a thorough review to verify the accuracy of the translation and its faithful representation of the original meaning. Three semi-structured interviews were conducted with stakeholders from Skellefteå municipality, Tillväxtverket, and Energimyndigheten. Two informal conversations were had with stakeholders from Skellefteå municipality and Tillväxtverket. The results of the interviews were entered into the coding manual.

### 3.3. Data analysis

The data analysis phase of this research is structured to combine the results from the document analysis and the semi-structured interviews.

Using the coding manual developed during the data collection phase, the data were systematically coded into pre-defined categories based on the analytical framework of the paper. These categories included market, regulatory, coordination, and technological barriers and risks. The dynamic coding process allowed for the addition of new codes that emerged during the analysis. Bryman and Bell (2019) describe various ways of deciding what needs to be analyzed. Since this is not a statistical paper, nor is the purpose to find out whether or not one barrier or risk is more commonly identified rather than another in the analyzed documents, little

weight was given to the frequency of certain words in the papers (for instance, one document may contain several hits for ‘market risks’ but none for ‘regulatory risks’) as specific terminology may be common in company documents but not as common in government documents. Instead, the document analysis took an interpretative approach, i.e., looking for the manifest content (direct mentions of risks) and latent content (e.g., implied concerns about the stability of raw material supply or hints at coordination challenges). This required a pre-defined definition of the four main barrier categories – what themes and sub-categories they represent. For instance, when it comes to market risk, a document might state that there is a risk that market fluctuations impact the value-chain. Such statements were then categorized under market risks. After the initial coding, the data was re-examined to identify common themes and patterns, and codes were grouped into broader categories that captured the main concepts, strategies, and issues related to transition risks and barriers.

### 3.4. Ethical reflections

The research did not present significant ethical dilemmas, and general ethical principles were followed. This involved informing the interview respondents about the research topic and purpose of the study, obtaining their consent, allowing them to withdraw from the interview or the study at any time, and seeking their permission to record the interview. Additionally, the respondents were informed about the measures taken to protect their confidentiality, the transcription of recorded interviews, and how the transcriptions would be stored.



## 4. Results

The following chapter presents the findings from the data collection. It examines the barriers and risks identified by Northvolt, the government, Energimyndigheten, Tillväxtverket, and Skellefteå municipality, along with their employed or suggested strategies to deal with these issues. See Annex A for complete list of results.

### 4.1. Northvolt

#### 4.1.1. Identified barriers and risks

##### *Northvolts risk perspective*

Northvolt categorizes risks into financial, compliance, strategic, and sustainability categories (Northvolt, 2021, 2022a). Strategic risks hinder the company from achieving high-level goals aligned with its mission and long-term objectives (Northvolt, 2021, p. 54). Financial risks are linked to the company's financial reporting and exposure to risks such as interest, liquidity, credit, and foreign exchange (p. 54). Compliance risks are related to adhering to laws and regulations, entailing the risk of financial and legal penalties resulting from non-compliance (p. 54). Additionally, sustainability risks are primarily associated with Northvolt's supply chain and sourcing of raw materials for battery manufacturing (Northvolt, 2022a, p. 37).

##### *Financial*

The two main financial risks Northvolt highlights (Northvolt, 2022a) are risks associated with financing and refinancing (p. 71). Regarding financing and refinancing, Northvolt identifies reduced access to capital markets as a factor that may slow down expansion projects. Furthermore, rigid capital structures cause inflexibility to maneuver in the future. Northvolt identifies “not meeting timeline or budget for

our expansion projects” as a factor that can harm their operations and that delays may risk “customer commitments and contracts,” which may change the “conditions for finance agreements” (p. 71).

### *Compliance*

Northvolt identifies compliance as a significant source of risk. The main risks involve adhering to regulations and laws, with potential financial and legal penalties for non-compliance (2022a, p. 70). Concerning product sustainability compliance, Northvolt points to the growing complexity of regional laws and regulations as a significant source of risk. Regarding risks related to human rights, Northvolt points to the risk that throughout the value chain and in some geographic regions, there is exposure to human rights violations and the related risk of breaking various laws and regulations during their multiple operations or throughout the value chain (p. 70).

### *Operational*

Northvolt (2022a) identifies operational risks such as supply chain and raw material sourcing, recruitment and upskilling, and customer uncertainties (pp. 69-70). Critical raw materials being dependent on countries outside the European Union poses a significant risk as Northvolt is exposed to “regulatory changes, restrictions on imports, [...], as well as increasing protectionism” (p. 69). Northvolt identifies these exposures as things that can lead to restrictions on supply availability. There are further risks associated with sourcing raw materials – Northvolt mentions the risk of suppliers not adhering to environmental, social, and governance standards (p. 69). There is also the barrier of a shortage of expertise in the industry; Northvolt highlights that their ability to maintain and grow their business hinges upon the contributions of “qualified employees” and “our efforts in upskilling our existing workforce” and to achieve their objectives the recruitment of “sufficient competent staff” is required (p. 69). Customer uncertainties are a risk that Northvolt faces; they highlight that customers may face changes to their needs from battery cells and purchase dates, which could impact both their “business operations and timelines” as well as their “financial and operational business plan” (p. 69). Furthermore, Northvolt states that “potential delays in ramp-up of production may also result in customer uncertainty” (p. 69).

### *Strategic*

Northvolt (2022a) highlights several strategic barriers and risks related to macroeconomic development, geopolitical tension, product development, and joint ventures. Regarding macroeconomic developments and geopolitical tension,

Northvolt highlights that “political volatility, armed conflicts, and geopolitical tensions have increased in the last year” (p. 68). The main risks identified as a cause of this are “sanctions, inflation, supply chain rerouting” and “increased raw material component and freight prices” (p. 68). Northvolt states that it has not been immune regarding Russia’s war on Ukraine and its effect on global supply chains and energy and raw material prices (p. 8).

Northvolt highlights the risk that joint ventures, partnerships, and other forms of cooperation, such as securing “market shares, supply, and development,” could turn out to be “non-successful and not deliver expected benefits” (p. 68). On the other hand, Northvolt also acknowledges the risk of missing opportunities in partnerships and strategic alliances (p. 68).

### *Sustainability*

As part of Northvolt's risk management, Northvolt analyzes climate-related risks using two scenarios. The first scenario, Net Zero Emissions by 2050 (NZE), developed by the International Energy Agency, represents a fast transition to a net zero emissions economy with the achievement of universal energy access. The second scenario, RCP 8.5, developed by the Intergovernmental Panel on Climate Change, represents a pathway with limited climate policy, an energy-intensive industry, and dependence on fossil fuels (Northvolt, 2022b, p. 9).

Beyond these scenarios, Northvolt highlights four other areas of sustainability risk. There is the risk of a significant environmental, social, and governance incident at one of their suppliers, as the “upstream battery value chain holds high environmental and social risks for some materials, [...] components, and geographies” (Northvolt, 2022a, p. 72). As battery manufacturing is an energy-intensive industry, Northvolt highlights that their operations could leave a high carbon footprint, as “some of our materials and components hold high embodied emissions and are transported over long logistics routes” (p. 72). Furthermore, there is the risk of breaking environmental permits due to “significant incidents” at Northvolt production sites, which could “affect our ability to protect the environment” (p. 72). Lastly, rapidly changing market regulations and the company's sustainability performance expectations could lead to “failure to comply with new sustainability-related requirements” (p. 72).

#### 4.1.2. Identified strategies

##### *Financial*

Northvolt highlights the importance of managing relationships with relevant stakeholders, as well as the importance of building further relationships with “potential new investors,” which includes “educating these partners to understand the business and potential risks in a proactive way” as a response to the risk of financing and refinancing (Northvolt, 2022a, p. 71). The respondent at Energimyndigheten mentions one way that Northvolt safeguards against financial risk is by off-take agreements, where other actors agree to purchase the product while it has not yet been produced, stating that Northvolt is thereby de-risking themselves financially. The respondent points to Volkswagen and their relationship with Northvolt and argues that Volkswagen cannot afford for Northvolt to fail. Northvolt is then better positioned regarding production delays (Respondent from Energimyndigheten, personal communication, 2024).

##### *Operational*

Northvolt highlights the importance of strengthening the European value chain and accelerating technical developments through joint development activities with other European companies as a way to minimize their dependency on raw materials outside of Europe (Northvolt, 2022a, p. 69). Regarding the workforce shortage, Northvolt emphasizes the need to recruit from a wider geographical area and the importance of training strategies to enable knowledge transfer and support (p. 69).

##### *Compliance*

Northvolt identifies three categories of compliance strategies related to governance, human rights, and non-compliance (Northvolt, 2022a, p. 71). Strategies for preventing compliance risks rely on “internal and external collaborations to ensure updates on latest regulatory requirements and market developments” (p. 72). Northvolt emphasizes maintaining good governance by monitoring performance and contractual agreements (p. 71). Northvolt works with risks related to human rights throughout the value chain by implementing preventative measures in geographic areas with higher exposure to human rights violations (p. 71). Northvolt emphasizes its high ethical standards and compliance with various laws and regulations through systemic measures, such as robust reporting mechanisms and internal controls (p. 71).



## *Strategic*

Northvolt emphasizes the need to diversify its supplier base further, to continuously monitor geopolitical developments, and to “take appropriate actions with suppliers and other stakeholders to reduce potential impacts” (2022a, p 68). Furthermore, Northvolt emphasizes monitoring the energy situation at their locations and the importance of “maintaining and establishing long-term electricity contracts and power purchase agreements” (p. 68). Northvolt (2021, p. 45) suggests that the energy transition will imply a shift from the dependence on fossil fuels to the reliance on metals. Northvolt has recently secured a joint venture to collaborate with the Swedish automotive company Volvo, aiming for “Volvo Cars to become a fully electric car maker by 2023” (Northvolt, 2022c)

## *Sustainability*

Northvolt employs several tactics to protect itself against sustainability risks, including comprehensive risk classification, the monitoring of various guidelines, engagement, communication with suppliers “to drive positive change” and to reduce their carbon footprint, the identification of “sources of environmental impacts,” and “providing awareness and training” (Northvolt, 2022a, p. 72). Regarding the risks related to raw material dependence in the value chain, Northvolt is expanding its capabilities to recycle batteries with the Revolt battery recycling program to secure a closed-loop feed of metals for cell production (p. 21). Northvolt (p. 21) highlights that this not only acts as a mitigatory measure towards sustainability risks but also mitigates compliance risks by lessening their exposure to risks regarding human rights often associated with the extraction of raw minerals. Northvolt states that since the start of construction in Skellefteå, it has engaged with the local Sámi community to ensure open dialogue surrounding its activities (2022a, p. 46).

## 4.2. Government

### 4.2.1. Identified barriers and risks

#### *Infrastructure*

In 2020, the government assigned a coordinator to promote the coordination of efforts for the significant major business establishments occurring in Norrbotten and Västerbotten (Regeringskansliet, 2020). The coordinator lists several infrastructure risks associated with larger establishments of industries. Increased inflation and interest

rates have led to the cancellation of new housing projects despite high demand (Näringsdepartamentet, 2022, p. 26). The government also emphasizes the housing needs required in areas such as Skellefteå (Regeringen, 2022, p. 21). Moreover, due to the nature of industrial establishments such as Northvolt, the investments required of the municipality are particularly more considerable than the typical investments usually associated with incremental development (Näringsdepartamentet, 2022, p. 35). Road and rail networks are crucial for municipalities to support significant developments by facilitating the transportation of goods and labor into the area (Näringsdepartamentet, 2022, pp. 26-27). The coordinator also highlights the issue of investments being required in infrastructure with the backdrop of uncertainty, emphasizing that Northvolt's establishment was not a sure thing despite the initial decisions made in 2017 (p. 34). The coordinator notes that the expansion of infrastructure causes a conflict of interest, as the needs related to new establishments may infringe on the needs of the reindeer herding industry and Sámi people (p. 51). Also highlighted is the issue of fly-in and fly-out (p. 34).

### *Competence*

The government identifies that an educated workforce is lacking within several occupational groups connected to energy, batteries, and digitalization (Regeringen, 2023, p. 110). The government also emphasizes the need for municipalities to recruit from the rest of Sweden to increase the overall regional workforce (p. 111). The coordinator underlines that “[n]atural mobility will be far too slow to meet this challenge. [...] it will require well-coordinated efforts involving authorities at different levels, companies but also other stakeholders” (Näringsdepartamentet, 2022, p. 36). The government states that for regions to be more attractive, attractive residential areas and commercial services must be established (Regeringen, 2023, p. 111). The government also notes that temporary housing, which leads to substandard living environments, should be avoided (p. 111). The government states that when needed, targeted actions should be implemented to strengthen the supply of skilled workers in connection with large establishments or expansions in parts of the country where a lack of competence would limit a green transition (p. 114).

### *Regulatory*

The coordinator highlighted the environmental review processes as a common issue among actors in various industries when establishing companies in northern Sweden (Näringsdepartamentet, 2022, p. 17). The coordinator points to Northvolt as a process that was usually highlighted as a positive example of the process (p. 18). The government emphasizes that shorter, more predictable, and effective permit processes are required to secure the competitiveness of businesses and increase the will to invest

(Regeringen, 2023, p. 74). The government emphasizes mining as crucial for Swedish competitiveness in the green transition as a supplier of raw materials to industry (p. 78). It underlines the opportunity for Sweden to lessen the need for third parties and the opportunity for higher ethical and sustainable raw materials (p. 79). Regulation also has an impact on a local scale; the coordinator highlights the municipal financing principle as an issue for municipalities, as it does not allow municipalities to finance activities that affect an individual in other municipalities, which is an issue for the municipality if the individuals which would need to be educated are native to another municipality (Näringsdepartementet, 2022, p. 21). Internationally, the government emphasizes the importance of standardization (Regeringen, 2023, p. 137). It states that ongoing international standardization efforts are focused on critical metals and minerals, sustainable mining, and sustainability issues throughout the value-chain and life cycle. However, no comprehensive approach is currently addressing these sustainability issues (p. 137).

### *Market*

The coordinator highlights municipalities' financial risk when engaging in large-scale establishments, hoping for positive population growth and increased tax revenue (Näringsdepartementet, 2022, p. 34). The government highlights that the transition and climate targets set internationally and by Sweden require significant investments and says that new forms of state aid in other nations have led to international competition for investments (Regeringen, 2023, p. 83). The government states that there is an unused potential for companies, municipalities, and regions to use national and European means for climate investments (p. 82). However, the government states that the “flora” of financial support can be challenging to navigate for actors and that there is a potential need to simplify access to these sources of financing (p. 82).

### *Coordination*

The coordinator emphasizes that with large establishments such as Northvolt, there are no people or physical conditions in place at the start (Näringsdepartementet, 2022, p. 29). The coordinator points to the need for coordinated efforts of several different actors and that the success of large establishments in northern Sweden depends on whether these actors can cooperate and pool their respective resources (pp. 36-37). The coordinator also highlights the complexity of large establishments and that this leads to several actors who will not have an overview of everything that is happening (2022, p. 38). The government also highlights the need for the government, state administrative authorities, regions, and municipalities to consult with Sámi representatives on matters that may have particular significance to them (Regeringen, 2023, p. 62).

## 4.2.2. Identified strategies

### *Infrastructure*

In its latest 2024 budget proposition, the government proposed a temporary stimulus package to municipalities that adopt plans to refit premises to housing (Regeringen, 2023, p. 107). To give municipalities better conditions to plan for sustainable environments and cities, the government decided in 2022 to add 15, 30, and 40 MSEK (million Swedish Kronor) in the respective years 2022, 2023, and 2024 to support “innovative, inclusive, and sustainable” housing projects (Regeringen 2022, p. 18). The coordinator (Näringsdepartamentet, 2022, p. 35) emphasizes that the EU Just Transition Fund (JTF) could partially meet the municipalities’ need for financing but highlights that the municipalities themselves cannot handle applications to these complex mechanisms.

### *Competence and market*

In 2021, the government gave Energimyndigheten the mission to support Northvolt with 238 MSEK to build a research campus (Regeringen, 2022, p. 33). The financial aid is connected to Sweden’s and Northvolt’s participation in the European project EuBatin (European Battery Innovation), which has led to increased and deepened European cooperation, as the government states (p. 33).

Together with Lunds University, Uppsala University, Chalmers University of Technology, and the business community, the government has strategically developed long-term research and education environments within electrification and battery technologies (Regeringen, 2023, p. 120). This allows the universities to recruit individuals with key competencies (p. 120). Moreover, the government provides students with ‘finance for transition retraining’ to help individuals strengthen their skills by pursuing education in high-demand areas (Regeringen, 2022, p. 104).

### *Circular economy*

The government emphasizes the importance of the battery industry sourcing minerals from secondary sources. This necessitates a greater focus on recycling and repurposing mining waste (Regeringen, 2022, p. 74). The government also prioritizes establishing circular pathways for valuable materials that could pose challenges if they end up as waste (p. 75).

## 4.3. Energimyndigheten

### 4.3.1. Identified barriers and risks

#### *Regulatory*

Energimyndigheten describes the issue of raw material dependence in the value chain as an issue for the success of the battery industry (Energimyndigheten, 2023c, p. 12; Energimyndigheten, 2023e, p. 55;). Energimyndigheten (2023c, p. 12; 2024, p. 4) highlights the barrier that raw materials used for battery production are under intense competition. Energimyndigheten emphasizes the industry's need to optimize raw material use and develop climate-friendly recycling and reuse processes to reduce overall consumption (Energimyndigheten, 2024, p. 4). That there are gaps in the European value chain regarding critical raw materials makes the Swedish battery industry vulnerable to external regulatory changes:

*For example, if Europe puts high import duties on Chinese vehicles, as many want, what happens then? You can imagine China counteracting by saying that our battery factories will not be allowed to buy raw materials. (Respondent from Swedish Energy Agency, personal communication)*

Another way global politics can influence the continued development of the Swedish battery industry is through fiscal policies such as the Inflation Reduction Act (IRA). As mentioned in the interview, several projects due to settle in Sweden, have not done so and have chosen to go to the United States instead. Speaking on state aid, the respondent says that:

*France [...] has done so, and Germany. But Sweden has not done so, and we do not consider that we can afford to do such things, so there are gaps there in terms of how people view state aid as not being good. At the same time, we have the United States and China doing it, so the market is affected by this regardless of what we do. What happens now when Sweden may not match is that investments go elsewhere. That is what is happening de facto. (Respondent from Energimyndigheten, personal communication)*

The respondent also mentions legislation as a barrier and points to the fact that the high sustainability standards in Sweden make setting up mines difficult. The

respondent continues by stating that while it is, in relative terms, easy to find finance for a battery factory, it is much more challenging to find financing for a mine.

### *Market*

Energimyndigheten states that actors who are first to act (i.e., a company introducing a new technology before others in the market) are more at risk as they may end up outside the traditional value-chain (Energimyndigheten, 2023e, p. 51). Furthermore, there exists a great deal of uncertainty for investors who may consider the risks of investing too great, which acts as a significant market barrier for Northvolt (p. 51)

### *Technological*

The respondent from Energimyndigheten identifies the risk related to being a ‘first actor’ as a technological risk; specifically, there is an inherent risk that the new technologies being developed might fail or not work as expected. There is usually high uncertainty related to the establishment of new industries, and to secure funding and support, pilot projects and demonstration facilities may be needed to showcase the potential and functionality of the product, states the respondent. The respondent says this is because batteries are a commodity acquired by companies such as Volvo for incorporation into EVs, which mandates prompt access to battery technology. The respondent suggests that simply proposing the concept of a battery is useless for establishing enduring partnerships and securing sales; the batteries have to be available and tangible from the start. Another technological risk is related to the reuse and recycling of products. Energimyndigheten, speaking on the industry as a whole, emphasizes the need to develop processes to minimize overall material and resource consumption through recycling and remanufacturing (Energimyndigheten, 2024, p. 4).

### *Competence*

Energimyndigheten emphasizes the need for increased funding for research in several of the documents (Energimyndigheten, 2023c, p. 36; Energimyndigheten, 2023b, p. 17; Energimyndigheten, 2020, p. 2). In 2020, Energimyndigheten stated that the lack of funding in the latest budget bills reduced funding for research and innovation (Energimyndigheten, 2020, p. 2). More recently, Energimyndigheten again highlighted the need for increased funding to “create appealing research environments capable of attracting talent” and “facilitate collaboration between institutes of higher education, research institutes, and the business sector. (Energimyndigheten, 2023c, p. 36). The need for increased funding is mentioned as a strategic priority (Energimyndigheten, 2023b, p. 2).

Energimyndigheten emphasizes the lack of workforce and skilled workers in the battery industry as a barrier (2023c, p. 36; 2023a, p. 29; 2023d, p. 21). The need for skilled labor within the battery industry varies and ranges from engineers to skilled labor jobs, and it is needed throughout the value chain (Energimyndigheten, 2023b, p. 18). Another difficulty is anticipating which competencies will be required as the industry is still in its early stages (p. 18). The lack of workforce is mentioned as a direct influencing factor in the success of the transition, and the lack of workforce and competence risks slowing the transition down (Energimyndigheten, 2023a, p. 29; Energimyndigheten, 2023c, p. 40).

### *Coordination*

Energimyndigheten emphasizes collaboration in research and innovation as essential for “achieving a wider perspective and a breakthrough for the transition (Energimyndigheten, 2020, p. 4). Energimyndigheten continues, “[m]ore collaboration is required between providers of research and innovation, both from academia and the business sector, on the one hand, and users, clients, and investors in society on the other” (p. 7). A holistic view, a systems perspective on the energy field, and strengthened connections between relevant research and energy-related climate policy efforts are necessary (Energimyndigheten, 2023b, p. 17). Moreover, there is a need to coordinate at local, regional, and national levels to promote a just, sustainable, and inclusive transition, with a particular focus on the Sámi people (Energimyndigheten, 2023b, p. 52).

#### 4.3.2. Identified strategies

### *Sustainability*

Energimyndigheten has invested in Northvolt's Revolt, a pilot demonstrator factory designed for a new recycling process to produce lithium batteries (Energimyndigheten, 2023a, p. 79). The respondent stressed the importance of recycling materials for reuse in production, citing its significant sustainability benefits. Additionally, it was noted that this approach helps Northvolt to safeguard itself against potential shortages of raw materials.

### *Technological*

Pilot plants are one way to demonstrate the feasibility of major-scale industrial productions. Energimyndigheten runs a Pilot and Demonstrator Initiative, which

“aims to facilitate the introduction, up-scaling, and dissemination of new energy innovations to the market (Energimyndigheten, 2023c, p. 29). Energimyndigheten offers support to larger pilot facilities, system demonstrations, and larger prototypes, as testing a solution on a small scale to its establishment in society can take time and have effects on other parts of the system that are difficult to foresee (Energimyndigheten, 2023a, p. 85). The Pilot and Demonstrator Initiative thus helps demonstrate solutions at a large scale in a relevant environment (p. 85).

### *Coordination*

The respondent emphasizes the value and importance of a national battery arena to enhance competence. The battery arena serves as a platform for potential entrants into the battery industry to gain insights into the ecosystem, existing policies, relevant actors, and sources for research and innovation financing. This type of program promoting cooperation and partnership has other benefits; Energimyndigheten (2023a, p. 21) stated that collaboration between the agency and external actors early in the development process has helped investments become more effective and have a more significant impact. Energimyndigheten also invests in competence centers within the energy sector to foster long-term research relevant to sustainable energy systems (2023a, p. 74). Within the areas of batteries, Energimyndigheten also highlights international cooperations as opportunities for actors to participate and have a say in a European context in areas such as politics and system development (2023a, p. 80).

### *Market*

A stakeholder at Energimyndigheten states in an interview at Svenska Dagbladet (2023) that public funds have acted as a key in the early stages of the establishment of Northvolt by minimizing the risk for other actors. Several investors stated that if they were to enter and invest in the pilot plant, Energimyndigheten also had to invest (Svenska Dagbladet, 2023). Energimyndigheten states that the Industrial Leap (*Industriklivet*) is an important springboard for other investors by reducing economic risk (Energimyndigheten, 2023e, p.51). Energimyndigheten finds that several stakeholders who worked for companies that had been granted funds from the Industrial Leap stated that it had a crucial symbolic effect (p. 43). By entering at an early stage as a supporting actor, legitimacy is established with new financiers and may also remove uncertainties and increase the will for other actors to take on risky investments (pp. 43-44).

Speaking on Northvolt’s risk strategy, the respondent mentions that as time goes on, investments into the battery industry will generally be less risk-filled than today as the market segments and use cases for batteries will grow. The respondent



states that as the market grows, the economic sustainability of so-called “Giga” factories increases as they can move from producing primarily for one market segment (e.g., EVs) into other growing markets, such as battery storage.

## 4.4. Tillväxtverket

### 4.4.1. Identified barriers and risks

#### *Regulatory*

Tillväxtverket points out that structural barriers exist when new innovative solutions meet already established industry interests, standards, and regulations, as these either take time to change or are expensive to challenge (Tillväxtverket, 2023a, p. 15). This mismatch is pointed out by the respondent at Tillväxtverket, who states that our standard systems are not built to deal with the transition (personal communication). They explain that regions in northern Sweden are waiting for a strategy for the transition but that it has not yet been developed. Furthermore, the respondent notes that the Swedish state is good at managing transitions when industries shut down but that no such process or plan exists for the transition in northern Sweden.

According to the respondent, the establishment of Northvolt in Sweden is not due to any work from the Swedish state to invest there but rather the result of Skellefteå realizing that something had to be done to reverse the migration trend from the municipality (personal communication). The respondent continues to state that there is a lack of government support for the transition in northern Sweden, mentioning a loan Skellefteå got for housing from the EU:

*The European Commission has understood that the public sector needs capital when there is a significant transformation. But Sweden has no equivalent.*  
(Respondent from Tillväxtverket, personal communication)

#### *Technological*

The supply of skills or competence is a general challenge for regions such as Västerbotten and Norrland (Tillväxtverket, 2023a, p. 15). Tillväxtverket highlights that research-intensive companies, especially those that work with advanced technologies, have to compete globally for the best researchers and talents (p. 15). The respondent states that it is not possible to recruit people with the specific skills required from the region of northern Sweden and that to get the necessary competence,

individuals will have to move there. Another issue is that the industry does not know precisely what competence is required:

*80% of the skills needed are at the secondary level, while only 20% are at a high level of education. Northvolt did not believe that. At the start, they said we need 80% engineers. But they would not have gotten engineers to stand as process operators. It makes forecasting difficult because not even the industry can say what they really need* (Respondent from Tillväxtverket, personal communication).

The respondent continues that the municipalities do not have the necessary competence to support a transition on the scale happening in northern Sweden, stating that the region lacks knowledge or experience of large expansions.

### *Coordination*

Tillväxtverket (2022, p. 2) emphasizes the lack of communication between actors and that societal support systems are not built for a sudden transition. The respondent illustrates several actors with diverse mandates and regulatory frameworks that make it challenging to align efforts, using their efforts to improve competence as an example. The respondent highlights the group as consisting of several agency actors responsible for education. In the context of these types of cooperative efforts, there is a significant barrier in the inability to mandate changes in regulations such as those enforced by the National Agency for Education, which poses an obstacle to collective action aimed at addressing the competence shortage, states the respondent. Another issue noted by the respondent is that because it is so even between the political blocks in the government, no decision can be made without compromise:

*No one can point with the whole hand. Everything has to be compromised. In a situation like this, it might have been better if there had been a substantial majority with a clear line to pursue* (Respondent from Tillväxtverket, personal communication)

### *Infrastructure*

Housing and lack of infrastructure are barriers that affect the competence supply problem in the region. The respondent states that there are too many barriers for someone to move there, citing the lack of housing as a cause. The issue is compounded for the municipality when there is a need for 40,000 workers, who all want to move with their families, as this can lead to the fly-in, fly-out phenomena, leading to the municipalities not gaining any taxes, states the respondent. Furthermore, the investments in infrastructure must be made before they can get any tax benefits, as the

investments must be complete before anyone can move there. Speaking on this sudden and urgent need for investments in infrastructure, the respondent states that:

*Northern Sweden has long been a region experiencing depopulation. So, it is [...] not a transition, it is a total transformation of the whole society* (Respondent from Tillväxtverket, personal communication)

The respondent argues that the burden and risk of the transition falls on the municipalities, and it is not up to Skellefteå to decide whether Northvolt expands its operations in Skellefteå. There is a risk that Northvolt might choose to expand elsewhere, leaving the municipality with unused housing and a reinforced port. Northvolt was attracted to Skellefteå due to their access to fossil-free electricity. However, the respondent points out that when Boliden, another large establishment in the region, was expanding, they were not guaranteed any electricity allocation due to the risk of it running out.

*Now electricity is getting scarce. [...] who wants to be here if there is not much electricity?* (Respondent from Tillväxtverket, personal communication).

#### 4.4.2. Identified strategies

##### *The coordinating role of Tillväxtverket*

Speaking on the role of Tillväxtverket regarding the transition happening in northern Sweden, the respondent states that Tillväxtverket acts as a coordinator for various authorities on a national level. The respondent states that Tillväxtverkets commissioned task for the transition came without money to support municipalities such as Skellefteå. The respondent points to the European Regional Development Fund and the European Social Fund and states that the government believes that these should primarily be used instead.

Tillväxtverket works to identify what regulations various actors find difficult to understand or apply (Tillväxtverket, 2023b, p. 32). This work is done in coordination with companies, the industry, and agency experts. It includes changes to existing rules and regulations by making them more straightforward and easier to understand, lessening reporting requirements, or establishing simplified permitting procedures (p. 32). The respondent mentions how Tillväxtverket has acted as an

intermediary between Skellefteå and the European Investment Bank and helped in the process of Skellefteå being granted a loan for 800 MSEK.

The respondent states that it is not within Tillväxtverket's prerogative to directly grant aid to companies such as Northvolt. Instead, Tillväxtverket is more involved with peripheral organizational work. The JTF is highlighted as beneficial for Skellefteå and Northvolt, as it has provided a project with short courses so that people who have not worked in the process industry can take intensive courses and start working at Northvolt. The respondent states that enabling and coordinating these types of efforts is the type of "peripheral organizational" work that Tillväxtverket is involved in.

*We have a few different tentacles out there and try to help with what we can.*  
(Respondent from Tillväxtverket, personal communication)

## 4.5. Skellefteå municipality

### 4.5.1. Identified barriers and risks

#### *Competence*

Skellefteå has a low degree of unemployment, around 50 percent lower than on average in Sweden (Skellefteå, 2023a, p. 15). They continue to state that this low capacity of the labor market will require an extensive influx of people to manage the increased need for competence (p. 15). However, the housing shortage in Skellefteå has made it challenging to recruit the necessary competence:

*I get reflections from Northvolt that it is not easy to attract an employee who currently lives in Mexico with special skills to come to Northvolt when we cannot offer exclusive accommodation.* (Respondent from Skellefteå, personal communication)

Difficulties also exist for the municipality and the public sector; Sveriges Kommuner och Regioner (SKR, 2023, p. 15) highlights the need for competence in healthcare, public transport, and social services.

#### *Infrastructure*

There is a massive need for housing in Skellefteå. The influx of businesses and larger establishments like Northvolt creates increased immigration and, therefore, more demand. With a population target of 90,000 inhabitants by 2030, seven to eight thousand living quarters will have to be built in 2023-2030 (Skellefteå, 2023b, p. 10).

The respondent from Skellefteå stresses that the housing shortage is one of the most significant barriers and calls it their “Achilles heel” (personal communication). The respondent states that this is a result of global events and points to the war in Ukraine as one reason that it is difficult to build housing:

*Increased interest rates, rising material costs, and unclear conditions. The government and parliament must focus on other things.* (Respondent from Skellefteå, personal communication)

SKR (2023, p. 6) also identifies interest rates and inflation as reasons developers are not starting new projects. In these circumstances, the housing developers feel they cannot demand the rent to make the housing projects profitable (personal communication). Skellefteå (2023b, p. 10) states that increased inflation, rising interest rates, and high energy and building costs have decelerated housing production in Sweden. SKR (2023) also points to inflation as a cause for the low housing situation but also emphasizes that the recent abolition of investment grants for housing construction has had a negative impact (p. 16).

Skellefteå emphasizes the need to reinvest in infrastructure and highlights the challenge of completing extensive investments before new populations move in or new houses are built (Skellefteå, 2023b, p. 33). In other cases, infrastructure planned for the future, such as the railroad between Umeå and Skellefteå, has to be built a lot faster than planned:

*We need the railway between Umeå and Skellefteå now, not in 2032.*  
(Respondent from Skellefteå, personal communication)

### *Fly-in, fly-out*

The respondent emphasizes fly-in and fly-out as a critical issue for Skellefteå, resulting from the region's lack of housing and infrastructure. The risk with fly-in and fly-out is that the municipality will incur increased costs as there is an increase of people working there (causing the need for expanded infrastructure: roads, electrical grids, water, etc.) without living there (SKR, 2023, p. 6). The issue for Skellefteå is that the tax benefits they would get end up elsewhere, as taxes are paid to the region where an individual is a resident, according to the respondent. Regarding the housing situation, Skellefteå is trying to address this situation by building “temporary housing.”

However, SKR (2023, p. 16) warns of the risks associated with this practice, stating that several of the companies that are constructing the new establishments are subcontractors to subcontractors and that there might exist a lot of economic crime and undeclared work, which is reflected in the increased alcohol and drug consumption, as well as prostitution.

### *Coordination*

The respondent states that conflicts regarding coordination between various actors happen, but it does not necessarily have to mean something negative; it is just a matter of differing perceptions and priorities. Here, the respondent emphasizes the importance of cooperation and a willingness to share information. The respondent points to the dangers of having a “cat and mouse” game over municipality limits, as what happens across municipality lines is also a benefit for Skellefteå. The respondent states that the most crucial aspect is the willingness to have an open dialogue.

### *Regulatory*

Regarding the risk of changing national regulations or laws significantly impacting their operations, the respondent states that there is always a risk. However, while risk is one thing, the probability is what matters:

*[W]hen you have a high risk and a high probability, that is when you should be worried, as that can end up costing you a lot. (Respondent from Skellefteå, personal communication)*

The respondent believes that changes in local legislation will not significantly impact their operations, but they acknowledge the potential impact of international laws and regulations. As an example, they mention the IRA passed in the United States. The respondent stated that due to the IRA, subcontractors for Northvolt opted to establish in the United States instead of Skellefteå. This shift may lead to more advanced technical industries choosing locations in the United States over Europe.

The respondent states that the government is good when it comes to taking care of industries when they are going bankrupt and points to the car industry in Trollhättan as an example:

*Then there are resources to care for [the industry][...] there is a package for that. (Respondent from Skellefteå municipality, personal communication).*

The respondent continues that there is no said package or support for successful developments and establishments. All of the above barriers only emphasize the sense that municipalities are taking the majority of the risk when it comes to major industrial establishments for the sustainable transition, a sentiment shared by Skellefteå, states the respondent. Moreover, SKR (2023, p. 22) argues that rigid laws and regulations make it difficult for municipalities to utilize expertise across organizational borders.

### *Sustainability*

SKR (2023, p. 17) emphasizes risks related to establishments, as large areas of land must be used for the factories. In the early stages of large establishments, SKR (p. 17) highlights the risk that if planned establishments are not constructed, large land areas will have been destroyed, leading to unnecessary destruction of nature. Furthermore, special requirements have to be considered, considering the establishment's impact on water; investments may be required in water and stormwater systems (p. 17).

#### 4.5.2. Identified strategies

##### *Infrastructure and fly-in, fly-out*

SKR (2023, p. 22) highlights the importance of changing how actors operate regarding infrastructure planning. Specifically, there is a need to shift from sequential to parallel procedures and focus on improving permit processes and implementing infrastructure investments. Moreover, SKR (2023, p. 21) argues that the government needs to act more proactively in the planning stages of establishments instead of in a reactive supervisory role. As the role of planning has been put on the municipalities, help from the government would help cut down costs and lengthy planning processes.

The respondent states that fly-in and fly-out will always be a problem to some extent. They also stated that some people would never move to Skellefteå and would not stay in the municipality if they were not working at Northvolt. According to the respondent, it is about making Skellefteå more attractive as a city. The development of Campus Skellefteå is emphasized as one way to make the municipality more appealing, as it is argued to attract people due to its “internationally leading research, education, and innovation environments, based on regional strengths that meet the needs of society and individuals” (Skellefteå, 2022, p. 17). Skellefteå (p. 17) also emphasizes the importance of enhanced collaboration with government agencies and academia. On a local level, competence will be addressed by study programs to address skills shortages. Skellefteå (2022, p. 16) states that educational opportunities must increase at the upper secondary level and be supplemented by specialist, flexible forms of education at a tertiary level.

## *Coordination*

Skellefteå (2022, p. 16) highlights the active efforts to attract skills by collaboration with agencies, academia, business communities, and the public sector. The respondent mentions the active efforts to acquire the necessary skills for the transition:

*Skellefteå will make an effort to go down and court civil engineers in Spain to ensure that they come to Skellefteå. The whole world is our field of work right now.*  
(Respondent from Skellefteå, personal communication)

SKR (2023, p. 19) mentions the work on the environmental assessment before the establishment of the Northvolt factory as a positive example of coordinating efforts. The processing time of the environmental assessment was significantly reduced by various agencies working in parallel instead of sequentially (p. 19). SKR (p. 20) continues to describe the efforts by Skellefteå working closely with the county administrative board during the initial phases of Northvolt's establishment regarding permit processes, highlighting the coordination efforts required during the establishment. At an early stage, the "transformation office" was established by Skellefteå in cooperation with Region Västerbotten (p. 20). This works as a meeting place where the two actors have worked on various issues related to education, population, and skills supply, as well as acting as an arena to facilitate dialogue with national and international actors (p. 20).

## *The need for evolving regulation*

SKR (2023, p. 22) suggests that the government should change legislation to allow municipalities and regions to expand their collaboration. This would allow municipalities to use shared specialist expertise or improve efficiency by having another municipality perform certain tasks (SKR, 2023, p. 22).



## 5. Analysis

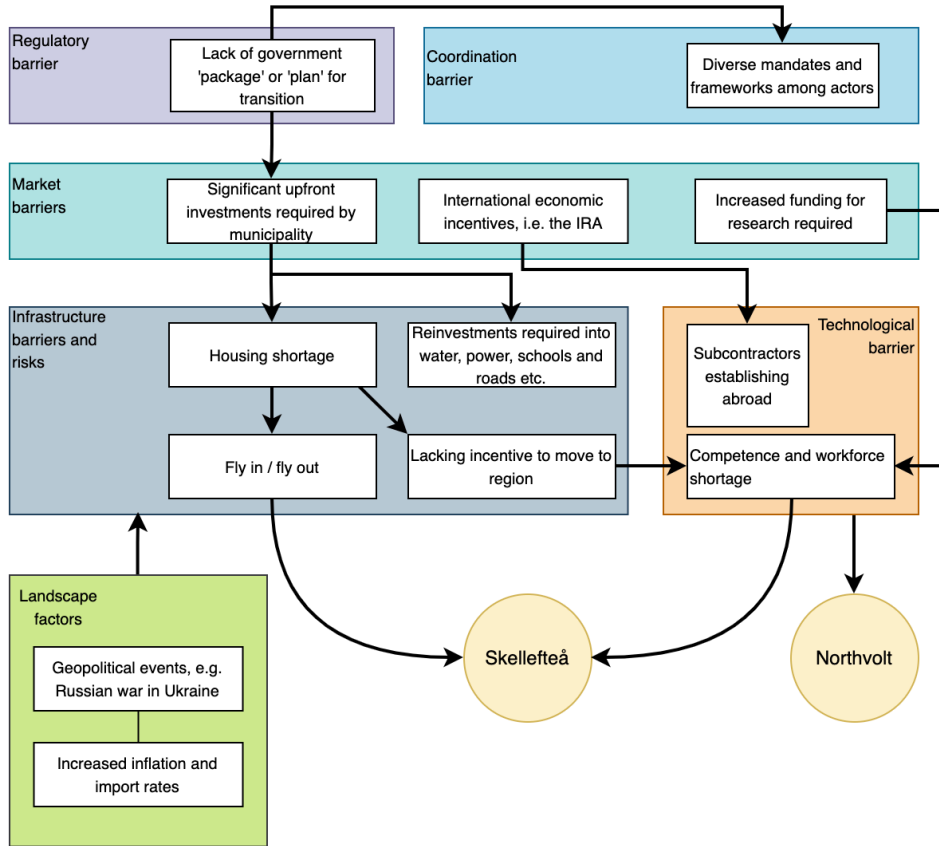
The results show that the framework established by Löfgren and Rootzén (2021) does not account for all barriers and risks in a transition such as the one occurring in northern Sweden. This is not surprising, as the focus of the article by Löfgren and Rootzén employs a company perspective. In contrast, this paper takes a broader perspective and focuses on a more comprehensive array of actors involved in the transition. Moreover, the results indicate that certain risks and barriers are not ‘static’ and do not belong to only one category (e.g., the IRA could be categorized as both a market and regulatory barrier). Furthermore, the results increase our understanding of how risks and barriers interact and impact each other. The research conducted in this study has identified two additional categories of barriers and risks that should be added to Löfgren and Rootzén's risk framework (2021). The categories of 'sustainability' and 'infrastructure' should be added alongside market, regulatory, coordination, and technological barriers and risks when examining transitions.

### 5.1. MLP and risk perspective

#### *Infrastructure*

Infrastructure is a barrier for both Skellefteå and Northvolt. Several actors identify the lack of housing in Skellefteå as a barrier, citing increasing inflation and interest rates as the leading cause. The respondent from Skellefteå points towards the war in Ukraine as an international issue having a local effect on housing. Skellefteå and Tillväxtverket emphasize that substantial investments must be made into infrastructure *before* anyone can move in. This requires significant upfront investments, something that the municipality has to shoulder. The respondents from Tillväxtverket and Skellefteå emphasized this as an issue of no ‘package’ or ‘plan’ for the transition. The infrastructure barriers for Skellefteå and the barrier of competence and workforce shortage for Northvolt have several other risks and surrounding ‘landscape’ factors that cause or exacerbate the issue (see Figure 2).

**Figure 2.** Illustrates the connections between various barriers, risks, and actors.



Landscape factors (in the sense of exogenous factors outside the control of a single or several actors), such as geopolitical events or increased inflation and interest rates, cause prices for building materials to go up. Lack of government funding causes significant risk for actors such as Skellefteå, as significant upfront investments are suddenly required to prepare the region for a massive influx of people. The risk of fly-in and fly-out causes a further financial burden for Skellefteå as they do not gain any tax benefits. The lack of infrastructure creates fewer incentives for skilled workers to move to Skellefteå, causing a shortage of competence and workforce in the industry and region. This is further aggravated by factors such as a downward education trend and the need for increased funding for research. The identified barriers and risks highlight the necessity of supporting infrastructure, as mentioned in the literature on risk (Löfgren & Rootzén, 2021, p. 195). In contrast to the literature on risk, the infrastructure support needed is not only directly targeted at technology adoption (such as charging

stations for EVs). Instead, broader infrastructure support is necessary to benefit the surrounding community in a sustainable transition.

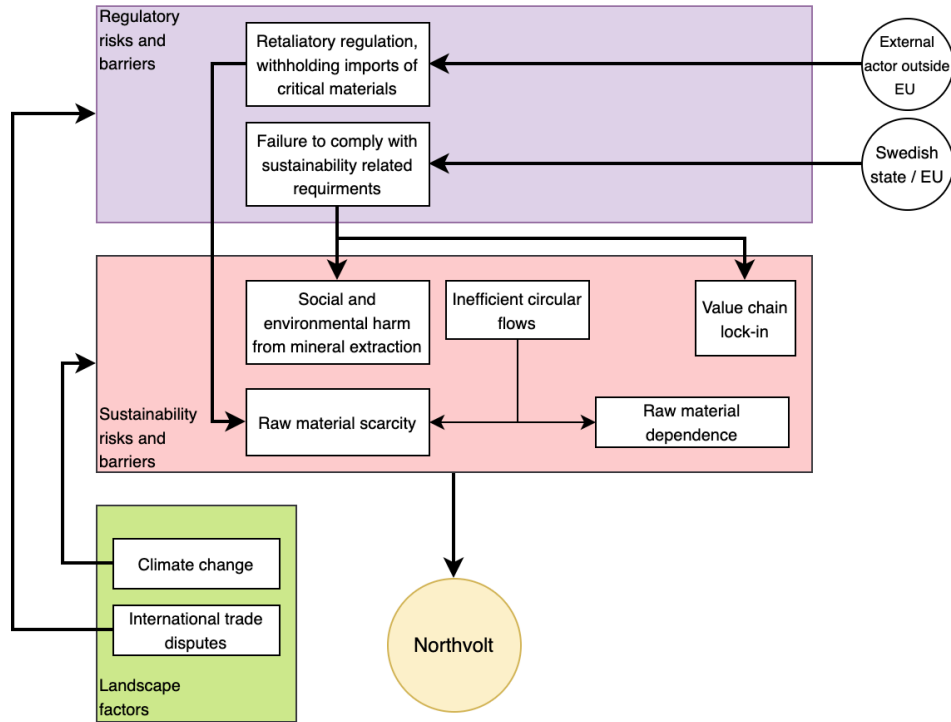
The infrastructure risks and barriers identified for Skellefteå place significant pressure on systems within the existing socio-technical regime, such as housing and transportation systems. Landscape factors exacerbate these infrastructure needs and illustrate the dynamic interactions between niche innovations, regimes, and landscapes. The changes required concerning infrastructure can be seen as the current regime being pressured to adapt to the needs of niche innovation.

### *Sustainability*

Sustainability barriers and risks are associated with environmental and social sustainability. Northvolt identifies several barriers concerning sustainability in the transition. These barriers generate risks along the value-chain, including the various risks related to raw materials, such as the scarcity of raw materials, which can significantly impact the production capabilities of companies such as Northvolt. The issue of 'upstream' sustainability risks relates to raw materials and the value-chain, representing the various risks associated with mineral extraction. Energimyndigheten states that gaps in the European value-chain cause vulnerability to external regulatory changes. The government states that there is a risk that valuable materials are turned to waste unless sufficient circular flows are established. Mentioned sparingly by Northvolt is the need to keep an open dialogue with the Sámi population, something that the government and Energimyndigheten also highlight as a necessity for a just transition. This aspect is crucial and thus integrated into the category of sustainability barriers, as a transition may represent significant social risks such as land use conflict and potential adverse effects on Sámi culture and livelihoods.

The issue of value-chains and raw materials emphasizes the interlinkages between the categories of barriers and risks (see Figure 3).

Figure 3. Illustrates the connections between various barriers, risks, and actors.



The scarcity of raw materials is interconnected with various regulatory risks imposed by many stakeholders and land ‘landscape’ pressures. The pressures from the ‘landscape’ could be argued to not only bring about ‘positive’ changes (i.e., financial stimulus for technological development) but also negative consequences as this same pressure increases demand for critical raw materials.

The increased focus on sustainable practices within the battery industry represents a change for the socio-technical regime that must adapt as traditional supply chain practices and regulatory standards are being challenged. Landscape changes, such as an increasing consumer demand for eco-friendly products, further drive this change. The joint venture between Volvo and Northvolt exemplifies what Geels (2019, p. 194) suggests: incumbent firms in the existing socio-technical regime can reorient towards greener niche innovations. These types of interactions suggest that an *integration* of niche and regime actors is combining to form a new system. It may also be representative of market barriers being influenced by ‘landscape’ pressures, as Geels (p. 194) argues that incumbent firms of regimes may reorient if they notice shifting consumer demands.

## *Regulatory*

Northvolt faces regulatory risks in the value-chain, which also connect with sustainability and market barriers, illustrating overlapping challenges (see Figure 3). Regulatory barriers and risks associated with the value-chain comprise the risk of human rights violations in the ‘upstream’ value-chain. Risks associated with the value-chain include import restrictions or sanctions, which, if realized, would become significant barriers for Northvolt.

Some risks are more difficult to place in one category; Northvolt identifies the risk of increased fuel taxation having a substantial effect on their upstream operations as they would have limited ability to change their dependency on fossil fuels in these instances; this acts as both a regulatory risk (the risk of fuel taxation) and a sustainability barrier (the barrier of being dependent on fossil fuels). The respondent from Skellefteå stated that they had judged the risk of any legislation or regulation change from the government has a significant impact on their operations as low; however, as noted by both the respondent from Tillväxtverket and Skellefteå, any type of government ‘package’ for the transition is missing. The respondent from Energimyndigheten states that one risk is how we are rigged for a “steady state” and that difficulties exist in optimizing against that (personal communication). This reflects the need for change highlighted by Löfgren and Rootzén (2021, p. 195), who state that government entities must adapt their frameworks and focus, as the current *modus operandi* reflects the structural systems of ‘existing technologies.’ The lack of adequate support systems suggests that the regulative rules of the transition, as mentioned by Geels and Schot (2007, p. 402), are still in the making and is further exemplified by Northvolt stating that changing regulation poses a risk (Northvolt, 2022a, p. 70) and the government pointing out the need for standardization in the upstream value-chain (Regeringen, 2023a, p. 137). No approach towards standardization has comprehensively addressed these sustainability issues, which indicates the socio-technical regime being ‘locked in.’ This ongoing reconfiguration of regulations is also symbolic of what Geels (2018, p. 88) argues is representative of transitions: incremental regime improvements. The regulatory barriers and risks illustrate the difficulties of ‘niche’ innovations breaking into established socio-technical regimes.

## *Market*

Northvolt (2022a, p. 71) emphasizes risks tied to financing and project delays. These risks highlight the vulnerabilities of emerging ‘niche’ technologies, which may require time and substantial investments to mature. This finding emphasizes the importance of the government’s recommendation that circular economy ventures need to be supported to reduce dependence on raw materials. Moreover, Northvolt (2022a, p.

71) mentions “rigid capital structures” as a financial risk, which indicates an issue faced by ‘niche innovations’ in the socio-technical regime.

Northvolt faces risks due to its reliance on raw materials, which could threaten the sustainability of batteries. This creates a 'lock-in' scenario, leaving the company vulnerable to potential future taxes on fuel and limited options to reduce its dependence on fossil fuels. The issue of 'lock-in' exemplifies the concept proposed by Kitzing et al. (2020, p. 378) that technologies are embedded in “larger socio-technical system[s].” This embedding exposes the viability of technological innovations to risks beyond their deployment, as adaptations are also necessary for raw materials extraction.

Increasing inflation, interest rates, and high energy costs have significantly impacted the availability and production of housing in Skellefteå. International fiscal stimulus packages, such as the IRA, lead suppliers and companies to choose not to establish themselves in Sweden and go elsewhere instead. The risks and barriers associated with the market illustrate how intertwined the categories of barriers and risks are. The concept of 'lock-in' and the influence of international incentives like the IRA can be considered regulatory risks and barriers, respectively, as the former pertains to the risk that fuel may become increasingly taxed, and the latter relates to existing laws and support systems. Within this context, market barriers are heavily influenced by regulatory barriers, which significantly impact marketplace barriers.

The risks associated with 'lock-in' and issues such as human rights and environmental issues along the value chain are therefore symbolic of the inherent risks that present 'niche' actors operating within socio-technical regimes, as it has not yet adopted sustainable practices.

### *Coordination*

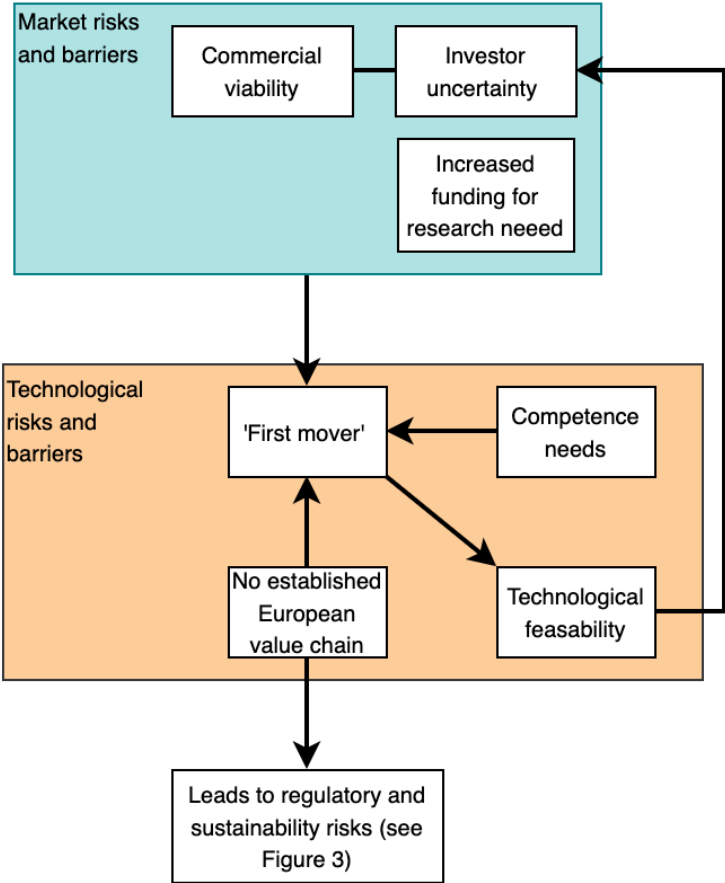
Lack of coordination can limit what Löfgren and Rootzén call “timely deployment of support infrastructure” and alignment of efforts across the supply chain (p. 196). The respondent from Energimyndigheten speaks on the importance of the battery arena in facilitating coordination between actors and helping them navigate the rules and regulations of the battery industry. The “transformation office” established by Skellefteå in cooperation with Region Västerbotten is indicative of the work done in the municipality to influence the transition when they have what Fischer and Newig (2016, p. 14) call “weak agency” and exemplifies the active role taken by the municipality within that context. The respondent from Tillväxtverket highlights the difficulties in coordinating efforts between several actors with different mandates and regulatory frameworks. This finding reflects Geels and Schot's (2007, p. 402) suggestion that the rules that coordinate niches and regimes differ, as the rules for the battery industry are still “in the making.” Specifically, what Geels and Schot (p. 403) call normative (comprised of relationships, values, and behavioral norms) and cognitive (belief systems, innovation agendas, and problem definitions) rules are still

unfinished. The established organizational structures and supply chain practices within the current socio-technical regime are either changing or new structures are being created within the niche. These new structures may integrate with the current system or replace it altogether.

*Technological*

The respondent from Energimyndigheten reiterates what Löfgren and Rootzén (2021) and Johansson et al. (2021) underscore as inherent risks in being the ‘first mover’ in innovative technology development. These risks concern uncertainties of new technologies’ feasibility, implementation, and commercial viability. Consequently, this adds to customer uncertainty and may impact the success of Northvolts’ operations (see Figure 4).

Figure 4. Illustrates technological risks and barriers.



This study suggests that a lack of competence is a technological barrier. The lack of competence affects technological development and, consequently, innovation. It is argued to be a technological barrier in contexts where technological advancements and innovation play a significant role in the development of the battery industry.

Northvolt states that its ability to grow hinges on several factors encompassing competence risks, such as its ability to upskill its existing workforce and recruit “sufficient competent staff” (2022a, p. 69). The need for the training of new competence also exists and is aggravated by the issue of being a ‘first’ mover, which reflects the difficulties surrounding the education of a competent workforce, namely that it is difficult to know precisely what specific competencies and skills will be required in the future, as stated by both Energimyndigheten (2023b, p. 18) and the respondent from Tillväxtverket.

The development of batteries and the establishment of the surrounding industry are suggested to represent niche innovations that challenge the socio-technical regime's existing technological infrastructure and pressure it to change.

## 5.2. Policy suggestions

This section covers the primary suggested policies and strategies that have either been implemented or suggested as necessary for a successful transition (see Table 2). While some of the suggestions may not apply to different contexts than Skellefteå, most of the strategies apply to other regions and future large establishments.



**Table 2.** Barrier and risk mitigation strategies.

<b>Policy area</b>	<b>Specific recommendations</b>	<b>Applicable to</b>
<i>Infrastructure</i>	Increase investments in local and regional infrastructure	Skellefteå
	Implement targeted funding programs for infrastructure upgrades	Skellefteå
<i>Workforce and education</i>	Develop targeted, specialized training and education programs with local universities and vocational schools	Both
<i>Regulatory framework</i>	Simplify and expedite the permitting process for new industrial projects	Both
	Establish clear and consistent regulatory framework for the battery industry	Northvolt
	Examine regional and national regulatory frameworks to facilitate cross municipality coordination	Skellefteå
	Assess permitting process and viability of sustainable domestic mining	Northvolt
<i>Environmental policies</i>	Support circular economy to reduce raw material dependency	Northvolt
<i>Coordination and governance</i>	Create a dedicated coordination body to manage various aspects of industrial transitions	Both
	Foster partnerships and exchange of know-how between the government agencies, private sector, and municipalities	Both
	Engage local communities in planning and decision-making process	Both

When considering the broader socio-technical system, the results identify several areas where it is suggested that specific strategies be employed and policies implemented when considering future establishments. Investments from Energimyndigheten at an early stage of the transition can signal to other actors that it is safe to invest. That investors required Energimyndigheten to invest alongside them further supports the idea of the state as a ‘leading’ actor. However, the lack of a ‘package’ for northern Sweden, especially in areas with significant establishments like Skellefteå, has made the transition more challenging and does not support the conceptualization of the state as a ‘leading actor’ in the transition. Conversely, the active work by Skellefteå regarding Northvolts establishment expands the understanding of the role and agency of regional actors in socio-technical transitions. The main issue identified is that the municipality

needs to make significant upfront investments into infrastructure to facilitate large establishments, which means the municipality is taking on high risk. In this case, the state should take on a proactive role, similar to its support for companies, by recognizing the inherent risks associated with transitions for municipalities and providing planning and support *before* and *alongside* the development of large establishments. This can have the effect of increasing workforce supply and decreasing social vulnerabilities arising from temporary housing.

Furthermore, the Swedish battery industry depends on critical raw materials from abroad. This dependency carries with it several sustainability, market, and regulatory risks. The expediting of the permitting process for opening mines should be carefully evaluated, considering the associated environmental and social risks and engaging with local communities in the process. Moreover, recycling initiatives such as Northvolt Revolt should continue to be supported to promote the reuse of materials and reduce dependency on international imports. Regional frameworks like the municipal financing principle should be reviewed to enhance municipal agency and promote cross-municipality coordination.

## 6. Discussion

### 6.1. Discussion of results and analysis

This paper examined how Northvolt and other actors perceive barriers and risks. Furthermore, it aimed to see which strategies, policies, and actions address the barriers and risks associated with the transition. The research utilized an MLP and risk perspective to frame the research. The findings of this paper argue that the categories of sustainability and infrastructure should be added to the risk framework. The findings also indicate that risks and barriers of different categories interact to a large extent and map out these connections. Finally, the paper proposes a policy mix for future large establishments.

According to Geels (2018, p. 88), transitions should not be viewed solely as a singular disruptive process driven by new technologies, as this perspective overlooks broader systematic transformations. Similarly, Kitzing et al. (2020, p. 378) contend that technology should be considered within the context of larger socio-technical systems, and transitions encompass changes that extend beyond the introduction of new technologies. The ongoing transition involving Northvolt in Skellefteå certainly gives this idea merit by demonstrating the extensive changes that go beyond the technological developments brought by Northvolt. Moreover, the different stages of transition (see Figure 1) have occurred at a much more accelerated rate than the span of decades that Geels (2019, p. 190) suggests they usually occur in. The period since the establishment of Northvolt in Skellefteå in 2017 until today encompasses characteristics from the *experimentation*, *stabilization*, and *diffusion* phases, with signs that it may soon enter the institutionalization phase. This suggests that consciously governed transitions can occur at an accelerated rate.

Moreover, characteristics of one phase may be present in another, suggesting that the various characteristics of each phase are not 'rigid.' The battery arena is envisioned as a collaborative space where stakeholders can engage in mutual learning and gain a comprehensive understanding of the sector. This initiative exemplifies a characteristic feature of the stabilization phase. Meanwhile, Northvolts collaboration with companies such as Volvo or support through the Industrial Leap from Energimyndigheten represents characteristics from the diffusion phase, such as support

from powerful actors within the dominant socio-technical regime or structural window of opportunity, respectively. That several characteristics of each phase can be found simultaneously suggests that the transition does not follow the linear structure and decades-long timetable usually associated with transitions but rather a more fluid process. Therefore, policymakers and industry leaders must consider the broader socio-technical context of transitions and not just focus on technological innovation. Furthermore, transitions can occur more rapidly, and each transition phase's characteristics are seemingly more fluid than traditional views suggest, necessitating increased flexibility and adaptability in planning, policy frameworks, and implementation to accommodate their dynamic nature.

## 6.2. Discussion of method

The paper used a deductive approach and employed data collection methods such as document analysis and semi-structured interviews. While these methods were considered suitable for the research aims and effectively provided the necessary information, certain things could have been improved. Some participants did not respond to interview requests, limiting the findings' scope. However, the available documents for the actors who chose not to participate in interviews was deemed sufficiently extensive for their inclusion. Surveys could have been beneficial as they would have allowed for a broader range of participants. The small number of respondents in this study could have affected the validity of the findings if document analysis had not been used.

Due to difficulties acquiring interviews with representatives from Northvolt and the Swedish government offices, this paper has, to the best of its ability, substituted this with the review of available documents. As seen in Table 1, the amount of publicly available material varied significantly among the actors. Despite the limitations, efforts were made to extract data from official reports and policy documents. While the absence of direct interviews imposed some constraints on the data collection process, the implemented adjustments have facilitated a sufficient understanding of the roles and perspectives of the various actors involved.

## 6.3. Future research

This paper lays the foundation for research exploring the broader implications of socio-technical transitions. Future studies can apply the expanded framework to include a broader array of national and international actors. Specifically, examining actors within the battery industry's value-chain and policy-making bodies within the European Union would be interesting. Incorporating these additional perspectives would give

future research a more nuanced picture of the barriers and risks associated with the transition to sustainable energy solutions. Investigating the role of international organizations, non-governmental organizations, and other relevant stakeholders could generate insights into the global dynamics at play. In addition to expanding the scope of stakeholders and geographical focus, future research should delve deeper into specific categories of barriers and risks, as this may help develop more targeted strategies to mitigate these risks effectively. Overall, expanding the scope and depth of socio-technical transition research would enhance our understanding of the complex risks, roles, and interactions between various stakeholders in progressing towards a more sustainable future.



## 7. Conclusion

The paper explored how various stakeholders perceived barriers and risks of transition by looking at Northvolt's establishment in Skellefteå using the MLP and risk perspective. A qualitative research design was employed, utilizing document analysis and semi-structured interviews. The findings contribute to the existing risk framework by introducing two additional categories of risks and barriers applicable to the transition in northern Sweden. It further expands the framework by examining how these barriers and risks interact. The analysis expands the MLP by developing insights into the roles of various actors and the nature of socio-technical transitions. Finally, the paper suggests policy recommendations for future large establishments in the transition.





# Acknowledgment

First and foremost, I would like to thank my supervisor, Roger Hildingsson, for his invaluable insights and guidance these past four months. I would also like to express my gratitude to all the respondents who participated in this study. Special thanks to Markus for the enlightening discussions that inspired this essay.



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## Annex

*Compiled results:*

*Annex A. Compiled list of results*

<b>Barriers and risks</b>	<b>Suggested strategies</b>	<b>Identified by</b>	<b>Applicable to</b>
<i>Financing and refinancing</i>	Off-take agreements Managing relationships with investors	Northvolt	Northvolt
<i>Not adhering to laws regulations and laws due to growing complexity and rigid structural systems</i>	Monitoring contractual agreements Internal controls Reporting mechanisms Simplified reporting requirements Simplified regulations Shorter, more predictable and effective permit processes Tillväxtverket acts in an intermediary role	Northvolt Tillväxtverket Regeringen Energimyndigheten	Both
<i>Environmental and social risks in upstream supply chain</i>	Engagement with suppliers Awareness and training Recycling	Northvolt Energimyndigheten	Northvolt
<i>Raw material dependency</i>	Diversify supplier base Recycling	Northvolt Energimyndigheten	Northvolt
<i>Lacking competence and workforce</i>	Training programs Recruit from wide geographical area Research campus Finance for transition retraining Investments into competence centers and research	Northvolt Regeringen Energimyndigheten Tillväxtverket Skellefteå	Both

	Battery arena Campus Skellefteå Study programs		
<i>Macroeconomic developments and geopolitical tension</i>		Northvolt Skellefteå	Both
<i>Lack of housing and infrastructure</i>	Targeted stimulus packages EU Just Transition Fund Temporary housing	Regeringen Skellefteå	Skellefteå
<i>Significant investments required by municipality</i> <i>Municipal financing principle</i>	National and European climate investments	Regeringen	Skellefteå
<i>Lacking coordination between actors</i>	Involve and consult with relevant actors Battery arena	Regeringen Energimyndigheten Tillväxtverket	Both
<i>New forms of state aid in other nations leading to increased international competition</i>	National and European climate investments	Regeringen Energimyndigheten	Both
<i>High uncertainty related to development of new technologies</i>	Pilot plants Industriklivet	Energimyndigheten Tillväxtverket	Both



*Interview guides:*

## *Annex B. Interview questions for Energimyndigheten*

Kan du berätta lite om din uppgift på Energimyndigheten, och hur länge du har jobbat med dessa frågor.

Lite övergripande; hur ser du på möjligheter och risker med den gröna industriomställningen?

På Energimyndighetens hemsida nämns det att en av riskerna för storskalig batteriproduktion i norra Sverige var att ”man inte lyckas knyta de strategiska partnerskap som kommer bli nödvändiga för genomförandet” – detta var skrivet 2020. Hur tycker du att det har gått?

Vilka strategiska partnerskap är det frågan om?

Händer det att vissa aktörer i dessa partnerskap har olika motiv / prioriteringar? Hur hanteras detta?

Hur hanterar Energimyndigheten utmaningarna med att få olika organisationer och företag att arbeta tillsammans mot gemensamma mål, särskilt när det gäller stora projekt som batteriproduktion? Är det ett problem?

År 2020 skrev du att en av riskerna var att kompetensförsörjningen kan bli en begränsande faktor. Kan du utveckla vad du menar med detta?

Om ja, hur arbetar Energimyndigheten för att aktivt lösa denna brist?

Hur hanteras olika utmaningar relaterade till etableringen av nödvändig stödinфраstruktur som krävs för etableringar såsom Northvolt?

Hur förhåller sig Energimyndigheten till risken för strängare lagstiftning eller ändringar i finansiering som potentiellt kan påverka befintliga projekt som Northvolt?

Hur ser ni på riskerna med att säkerställa en stark och välfungerande samverkan inom staten, akademien, och näringslivet för att hantera batteriindustrins snabba utveckling?

Vilka risker ser du av en sådan samverkan?

Vilka strategier finns för att hantera dessa risker?

Med tanke på de identifierade forskningsbehoven och den snabba utvecklingen inom batteriteknologi, vilka framtida risker och utmaningar förutser ni för den svenska batteriindustrin, och hur förbereder sig Energimyndigheten för att hantera dessa?

Finns det någon fråga du hade förväntat dig att jag skulle ställa som du inte fått? Något du vill tilläga?

### *Annex C. Interview questions for Tillväxtverket*

Hur ser Tillväxtverket på de utmaningar för en grön omställning och industriella etableringar som sker i Skellefteå och särskilt för företag som Northvolt?

Vilka utmaningar handlar det primärt om?  
Hur hanteras dessa utmaningar på bäst sätt?

Vilka regelverk och standarder upplever företag inom batteriindustrin som Northvolt som mest utmanande, och hur stödjer Tillväxtverket företagen att navigera dessa utmaningar?

Hur arbetar Tillväxtverket aktivt med att förenkla regelverk och tillståndprocesser för att underlätta industriella etableringar?

Hur bidrar Tillväxtverket till att säkertälla tillgången på tekniskt utbildad arbetskraft, särskilt för batteriindustrin och Northvolt i Skellefteå?

Hur bidrar Tillväxtverket till att förbättra infrastrukturen i Skellefteå för att stödja industriella etableringar?

*Annex D. Interview questions for Skellefteå municipality*



- Senast vi pratade nämnde du att Skellefteå och Northvolt 'har gått till kyrkan med varandra'. Kan du berätta lite mer vad du menade med detta?
  - Vilka möjligheter och positiva aspekter ser du med omställningen och etableringen av Northvolt för Skellefteå?
  - Ifall Northvolt skulle stänga ner, eller batteriindustrin på något sätt skulle fallera, eller inte ha den inverkan man hoppas på, skulle det kunna ha stora konsekvenser för den lokala ekonomin och för sysselsättningen. Hur tänker ni kring detta på Skellefteå kommun?
- Du nämnde att det nyligen togs ett beslut om att renovera hamnen i Skellefteå för 1,4 miljarder. Jag undrar hur Skellefteå kommun ser på ekonomiska risker i samband med all infrastrukturutbyggnad som krävs. Finns det en risk att de kostnader som Skellefteå kommun står för överstiger de ekonomiska fördelarna som förväntas med de nya etableringarna?
- Du nämnde i vårt tidigare samtal ett koncept som kallas för 'fly-in, fly out', vilket jag tolkar som en stor risk för Skellefteå – kan du berätta lite mer om hur detta påverkar Skellefteå?
- Kan det finnas något positivt, kortsiktigt, med att personer arbetar men inte bor i Skellefteå, i och med den bostadsbrist som finns?
- På tal om bostadsbristen, du kallade det er 'akilleshäl'; var detta ett problem som förutspåddes, tror du att man kunde ha planerat på något annat sätt?
- Finns det en kompetensbrist? Om ja, hur arbetar Skellefteå kommun aktivt för att lösa denna kompetensbrist?
- Om man läser runt lite så finns det vissa opinionsartiklar som argumenterar att Skellefteå kommun axlar en stor risk medan staten sitter lugnt i båten under den gröna omställningen. Håller du med om detta?
- Hur förhåller sig Skellefteå kommun till risken för strängare lagstiftning eller ändringar i tillståndsprocesser som potentiellt kan påverka befintliga projekt som Northvolt?
- Har Skellefteå kommun något samarbete med exempelvis andra städer, nationella regeringar, och/eller internationella organisationer för att hantera risker och dela praxis inom teknologiutveckling?
- Finns det någon fråga du hade förväntat dig att jag skulle ställa som du inte fått? Något du vill tilläga?



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