Integrating Capacity Analysis and Should-Cost Modeling to Enhance Procurement Processes

An in-depth understanding of the supply and cost structures of aluminum foil in North America

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Integrating Capacity Analysis and Should-Cost Modeling to Enhance Procurement Processes

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Lund, May 2024

Gustaf & Jakob

Abstract

In the rapidly evolving electric vehicle (EV) battery industry, strategic supplier selection is crucial for securing a reliable and cost-effective supply chain. This thesis examines the implementation of a capacity analysis and a should-cost model to optimize supplier selection and contracting for Northvolt, a leading battery manufacturer, as it expands into North America. With Northvolt's new gigafactory in Montreal poised to commence production in 2026, establishing a robust network of local suppliers is imperative.

The thesis focuses on answering one research question: How could a capacity analysis and should-cost model contribute to the supplier selection, negotiation, and contracting processes of Northvolt? To answer this question, two research objectives must be achieved. Firstly, a capacity analysis was made with the purpose of mapping out the existing and future production capacity of battery cathode foil, along with the projected demand, corresponding carbon offsets, and environmental ambitions for the future. Secondly, a should-cost model was made to provide a detailed breakdown of production costs, offering insights into cost drivers, and enabling more informed negotiation strategies with suppliers. To assist in answering the research question, qualitative data was gathered through structured interviews with Category Managers at Northvolt.

The thesis adopts an explanatory mixed method approach with focus on archival research and interviews to gather quantitative and qualitative data. Relevant actions have been taken to ensure reliable and valid results and analysis. The findings suggest that integrating these analytical tools significantly aids in making informed, strategic decisions in supplier management, setting a precedent for future procurement practices in the rapidly evolving EV battery sector.

Regarding the contribution, the thesis was conducted in complete collaboration between the two authors. Both authors have been fully involved in every process and section integrated into the thesis.

Keywords: Procurement, Strategic cost management, Category management, Should-cost model, Capacity analysis, Aluminum foil production, EV battery manufacturing

Sammanfattning

Inom den snabbt utvecklande industrin för elbilsbatterier är strategiskt leverantörsval avgörande för att säkra en pålitlig och kostnadseffektiv försörjningskedja. Detta examensarbete undersöker bidragandet av en kapacitetsanalys och en should-cost modell för att optimera val och kontraktering av leverantörer för Northvolt, en ledande batteritillverkare, inför deras expandering i Nordamerika. Med Northvolts nya fabrik i Montreal som är planerad att starta produktionen 2026, är etableringen av ett robust nätverk av lokala leverantörer avgörande för deras strategi.

Examensarbetet fokuserar på att besvara forskningsfrågan: Hur kan en kapacitetsanalys och en should-cost modell bidra till leverantörsval, förhandlingsprocesser och kontraktering hos Northvolt? Dessa leverabler analyserar produktionen av aluminumfolie, vilket är avgörande för produktionen av katoder i elbilsbatterier. För det första genomfördes en kapacitetsanalys med syftet att bedöma den nuvarande och framtida kapaciteten och miljöpåverkan av aluminumfoile hos potentiella leverantörer i Nordamerika. För det andra skapades en should-cost modell som ger en detaljerad uppdelning av produktionskostnaderna och kostnadsdrivare i produktionen av denna komponent. Dessa analyser hoppas kunna möjliggöra mer informerade förhandlingsstrategier med leverantörer.

Examensarbetet använder en förklarande blandmetodansats med fokus på arkivforskning och intervjuer för att samla kvantitativ och kvalitativ data. Detta innebär, med andra ord, att den kvantitativa forskningen och analysen genomfördes först. Sedan användes forskning och analys av kvalitativ data för att förklara relevansen och användadet av det kvantitativa resultatet. För att säkerställa tillförlitliga och relevanta resultat och analyser har relevanta åtgärder har vidtagits.

Slutligen, resultaten tyder på att integrationen av dessa analytiska verktyg avsevärt bidrar till att fatta informerade, strategiska beslut i leverantörshantering, och sätter en standard för framtida inköpspraxis i den snabbt utvecklande sektorn för elbilsbatterier.

Angående bidraget genomfördes examensarbetet i fullständigt samarbete mellan de två författarna. Båda författarna har varit fullt involverade i varje process och avsnitt som gått in i detta arbete.

Keywords: Inköp, Strategic cost management, Category management, Should-cost modell, Kapacitetsanalys, Aluminiumfoileproduktion, Elbilsbatteriproduktion

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Glossary and abbreviations

Glossary

Low-carbon aluminum: Aluminum made with a significantly reduced carbon footprint compared to the industry standard. There is no standard or defined carbon footprint that has to be cleared. The industry average is 15,1 kg CO_2/kg aluminum (International Aluminium Insitute, 2022).

Bauxite: Principal raw material used for the creation of alumina.

Alumina: Also known as aluminum oxide, is a white or nearly colorless crystalline substance that is commonly used as a basic raw material in the production of aluminum metal.

Primary aluminum: Aluminum metal made from bauxite.

Secondary aluminum: Aluminum metal made from recycled aluminum or alumina.

Semi-fabricated aluminum: Semi-fabricated aluminum refers to intermediate aluminum products that have been processed from primary metal to, for example, coils, sheet, automotive extrusions and so forth.

Metal coils: Metal coils are long, continuous strips of metal that have been wound into a coil or roll form. These can be used as **foil stock,** which is the name for raw material that goes into making foil.

Thin foil: Metal foil that has been rolled to a thickness of 5-20 μm.

Battery cathode foil: a thin metallic foil, typically made of aluminum, used as the supporting base in battery cathodes to hold the active material that participates in the electrochemical reactions during battery operation.

Scope 1, 2 and 3: These are emissions are categories defined by the Greenhouse Gas (GHG) Protocol. Scope 1 emissions are direct emissions from sources that are owned or controlled by the organization. Scope 2 covers indirect emissions from the generation of purchased electricity, steam, heating, and cooling consumed by the organization. Scope 3 emissions are all indirect emissions (not included in Scope 2) that occur in the value chain of the company, including both upstream and downstream emissions.

C-suite: The highest-ranking senior executives in a company. For example, chief executive officer (CEO), Chief Financial Officer (CFO) and so forth.

Value Chain: refers to the full range of activities that businesses perform to bring a product or service from its conception to its delivery to the final consumer and disposal, highlighting each step where value is added.

Logistics Chain: the sequence of processes involved in the movement, storage, and management of goods from the point of origin to the point of consumption, focusing on optimizing efficiency and meeting customer demands.

Tier X suppliers: Tier X suppliers represent different levels in the supply chain for manufacturing products. For example, tier 1 suppliers provide finished products or critical components directly to original equipment manufacturers (OEMs). Tier 2 suppliers produce parts or materials that are supplied to Tier 1 suppliers. Tier 3 suppliers supply raw materials or basic components to Tier 2 suppliers.

LME: The London Metal Exchange (LME) is a major marketplace in London for trading industrial metals. Prices, known as LME costs, are set for metals. LME premium is added to cover costs like storage and transport.

Abbreviations

GHG: Greenhouse gas

EV: Electric vehicle

GWh: Giga watt hours

kWh: kilo watt hours

SCM: Strategic cost management

SOP: Start of production

RFQ: Request for quotation

1 Introduction

The introduction chapter includes a description of the background and the problem along with the purpose of the thesis. Additionally, the research question and the corresponding objectives are described, followed by the scope and delimitations of the thesis.

1.1 Background

A supply chain encompasses a complex network of entities, including suppliers, manufacturers, distributors, and customers, involved in the creation and delivery of products or services from inception to consumption. According to Mentzer et al. (2001), it specifically refers to the interconnected framework of organizations directly participating in the sequential processes ranging from the procurement of raw materials to the delivery of final products to end-users. This network facilitates not just the physical movement of goods but also the flow of information and financial transactions across the supply chain's various stages.

The initial phase of the supply chain, known as sourcing or procurement, plays a pivotal role in determining a company's profitability and market success. Efficient sourcing requires a nuanced understanding of the supply market, referring to the availability in terms of quality and quantity and the strength positioning of existing vendors. This will enable the company to efficiently match the supply with the needs of the company. Arjan J. van Weele describes the importance of procurement as a critical function within organizations that influences both their financial results and their competitive advantage. Procurement involves managing the company's external resources efficiently to secure all necessary goods and services under favorable conditions (van Weele, 2022).

A major component in the procurement strategy is the process of selecting suppliers. The supplier selection process is a critical aspect of procurement and supply chain management by significantly impacting operational efficiency, cost management and overall competitiveness. This involves identifying, evaluating, and contracting suppliers who can provide goods and services which are in line with the requirements of the purchasing company. It is vital to ensure that the organization has a reliable, cost-effective, and qualitative supply base that supports the strategic objectives and operational needs (van Weele, 2022).

Following the implementation of strategic purchasing, firms can also opt to integrate strategic cost management tools to optimize their procurement operation. Strategic cost management (SCM) emphasizes creating value for customers and stakeholders by optimizing costs without compromising on quality or service. Furthermore, by managing costs strategically, companies can enhance their competitive advantage and ensure sustainable growth. There are several tools that can be used in this regard, such as the should-cost model which identifies and evaluates cost drivers in a product or service to estimate what the product or service should cost. This tool can help firms during supplier negotiations or help understand how to reduce costs internally. (Ellram, 2002)

1.2 Problem description

The battery-cell producing company Northvolt is planning on opening a new gigafactory in Montreal, Canada called Northvolt Six (Northvolt, n.d.). Construction has now started, and production is planned to begin in 2026. The company is otherwise based in Europe, which means that a new network of local suppliers must be developed. Given the background, the success of this task will have a substantial impact on the financial result of the North American expansion.

The category manager of foils, Max Hedsand, has been tasked with finding new suitable suppliers of aluminum foil for Northvolt for this factory. Aluminum foil is a key component in the production of their batteries and is specifically referred to as cathode foil. This thesis' task is to assist with the supplier selection process. The project will test how two deliverables can contribute to this process. The first deliverable this thesis will conduct is a capacity analysis of the relevant suppliers within the value chain of aluminum foil, including carbon footprint and outlook of aluminum foil production in North America. Also integrated in this analysis is a presentation of future demand of aluminum foil for the purpose of electric vehicle battery production in North America. The second deliverable is a should-cost model, which is a known practice but has not been created for this specific purpose. The ambition is that these deliverables will assist Northvolt ahead of negotiations with possible suppliers. The capacity analysis is necessary to evaluate that the capacity is sufficient, both in terms of actual supply volume and Northvolt's environmental requirements. The capacity analysis should emphasize the North American market, including:

1. Already installed capacity.
2. Capacity under installation or capacity being communicated to the market.
3. Carbon footprint associated with the respective capacity.
4. Future demand of battery cathode foil.

Following the capacity analysis, the goal of the should-cost model is, in addition to help facilitate negotiations, to assist Northvolt to better understand the underlying cost structure of aluminum foil produced in North America. The model's parameters can be later altered to facilitate other markets for future use.

1.2.1 The case company

The case company, Northvolt, chosen for this thesis is a relatively new player in the electric vehicle battery industry. They are a leading innovator in the green energy sector, specializing in the production of lithium-ion batteries for electric vehicles and energy storage. Founded in Stockholm, Sweden, in 2016 by ex-Tesla executives Peter Carlsson and Paolo Cerruti, Northvolt aims to revolutionize the energy landscape with the world's greenest batteries, leveraging renewable energy in its manufacturing processes. Its ambitious project, Northvolt Ett, is set to become one of Europe's largest battery factories, emphasizing sustainable production and ethical material sourcing. With strategic partnerships across the automotive and energy sectors, Northvolt is at the forefront of supporting the transition to renewable energy (Northvolt, n.d.). Because the company is relatively new, they have not yet implemented models such as should-cost analysis ahead of negotiations with new suppliers, making this thesis highly relevant and valuable for the company for their future operations (Hedsand, 2024).

Northvolt's purchasing organization

Northvolt's purchasing organization is based off a hybrid structure. There is a central organization based in Stockholm with decentralized units based at each factory. Northvolt has also adopted a category management approach that handles all contact with suppliers. The categories are split into several purchasing units that are responsible for different areas of Northvolt's business. This thesis works with the category for foils which is in the components and chemical purchasing unit. This unit oversees the necessary supply for manufacturing the batteries. There is also a purchasing unit for electrical systems, equipment, metals and more. Each category manager receives goals from the central organization that should be achieved. These include price, quality, quantity, delivery time, warranty terms, payment terms, liability and so forth. (Hedsand, 2024)

1.3 Purpose and research question

The purpose of this master's thesis is to conduct a capacity analysis and develop a should-cost model and analyze their respective contribution to the procurement processes of selecting suppliers and contracting.

1.3.1 Research questions

The aim of the study is therefore to answer the following research question:

RQ: How could a capacity analysis and should-cost model contribute to the supplier selection, negotiation, and contracting processes of Northvolt?

To answer the question, the following research objectives need to be accomplished:

RO1: Firstly, a capacity analysis of aluminum foil in North America is to be conducted, this includes:

i. Current and future supply of aluminum foil
ii. Corresponding carbon offset and environmental goals for the future
iii. Projected demand of battery cathode foil

RO2: Secondly, a should-costing model which aims to estimate the cost to produce aluminum foil at tier 1 suppliers.

By reaching these two milestones the main research question can be answered.

1.4 Scope and delimitation

The capacity analysis and should-cost model will only focus on the North American production of aluminum foil. When addressing aluminum foil in this thesis, it will refer to aluminum foil with a thickness of 5-20 μm. Also, aluminum foil that is used in EV batteries is referred to as battery cathode foil.

For the capacity analysis, all value-adding processes will be included in the analysis. The processes included are: bauxite mining, alumina refining, aluminum smelting, ingot casting, slab casting, hot rolling, and cold rolling. The processes can be viewed in figure 3.2. Furthermore, when assessing the carbon footprint of suppliers, scope 1, 2 and 3 emissions will be analyzed as well as climate goals and ambitions for the future. Lastly, for the demand aspect of the capacity analysis, the production included will be facilities producing one or more GWh equivalents of batteries.

For the should-cost model, only the production steps downstream in the value chain from the hot rolling process will be examined, which includes cold rolling, slitting, and packaging (see figure 3.2 for specifics).

1.5 Target audience

This thesis aims to make a scientific contribution to an unexplored and rapidly developing field. The main audience of this report is Northvolt, but also the academic community. Northvolt will be able to utilize and further build upon the capacity analysis and should-cost model that will be delivered from this thesis for their future operations all over the world. For the academic community, this thesis will become an example for how to conduct a should-cost analysis in this industry. The process of gathering data, analyzing, and building the model will assist future researchers.

1.6 Structure of thesis

Chapter 1: Introduction

The first chapter of the thesis presents the background of the problem as well as clearly describing what problem the thesis aims to solve. Additionally, the overall research question for the thesis is presented along with two research objectives that will help answer the question. Lastly, the scope, delimitation and target audience are presented.

Chapter 2: Methodology

This section details the research methodology, describing the adopted research approach, philosophy, strategy, and design. It does so with the help of Saunders' et al. "Research Onion" model to structure the methodology. The chapter also describes methods used when conducting the literature review, data collection, and data analysis stages of the thesis. Lastly, the robustness and reliability of the thesis is discussed.

Chapter 3: Literature Review

The literature review explores three main themes: purchasing strategy, the production process of aluminum foil, and the purchasing process. It provides comprehensive analyses of relevant theories and models, establishing a critical foundation for understanding the context and complexities of the thesis' subject matter. This chapter results in a literature framework that acted as guide when conducting the analysis.

Chapter 4: Empirics

Quantitative findings from the capacity and should-cost analyses are presented in this chapter together with qualitative data from interviews. The chapter begins by presenting the capacity analysis together with relevant information such as structure data gathering. Afterwards, the should-cost model is presented. Lastly, data from interviews is structured and presented.

Chapter 5: Analysis

This chapter examines the results from the empirical data in depth, including the capacity analysis, should-cost model, and their contribution for Northvolt's supplier selection process. Firstly, the implications of the capacity analysis are conducted, which presents carbon footprint impact and supply and demand dynamics. Secondly, the alternative use cases of the should-cost model outside of supplier selection are analyzed. Lastly, the interview data from chapter 4 is analyzed regarding the contribution the two deliverables provide to Northvolt's supplier selection and contracting processes.

Chapter 6: Conclusion

This chapter summarizes and concludes the findings of the thesis. The chapter firstly presents the answer to the research objectives and question. Secondly, the contribution of the findings to the case company. Thirdly, the contributions to academia. Fourthly, limitations and future research suggestions are presented. Lastly, the authors reflections of the thesis are described.

Chapter 7: Bibliography
This chapter presents all academic works, articles, and resources which are cited throughout the thesis. This provides a comprehensive reference list that supports the research conducted.

Chapter 8: Appendix
Supplementary materials such as detailed descriptions of the should-cost analysis process, capacity analysis company descriptions, and additional data that support the empirical research are included in the appendix.

This structure ensures a systematic investigation into the research problem and addresses the complexities involved in the procurement process for aluminum foil in North America.

2 Methodology

This chapter aims to describe and discuss the methodology of the thesis. To develop a structured and detailed research methodology, Saunders' "Research Onion" will be used. This model breaks down the different decisions that had to be made when developing the research methodology. When working towards the center of the "onion" several choices were made that range from high-level and philosophical to tactical and practical. It is a useful tool for thinking holistically about methodology. The model is presented in figure 2.1.

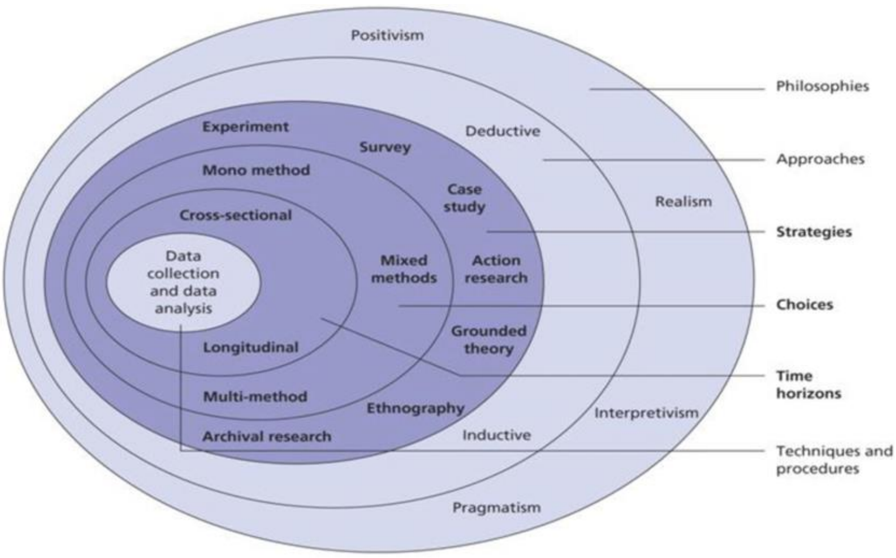

Figure 2.1: The Research Onion (Saunders et al., 2006, p. 102)

2.4 Research philosophy

The first layer of the onion examines the philosophy of research, which relates to the development of knowledge and the nature of knowledge. It describes the set of beliefs that the research is going to build upon. In this thesis, the aim is to adopt a positivist point of view, however this view might move towards the assumptions of constructivism (in other words subjective inquiry with multiple realities). The goal is to objectively understand the phenomena and the situation of the case company to present actionable results, but also how and why the actionable results are useful for the company. (Saunders, et al., 2006)

2.5 Research approach

In this thesis an abductive research approach was adopted since there was no pre-formulated hypothesis to be tested. Instead, hypothesis and theories was generated through conducted research, and was tested to ensure they form the best explanation of our case (Saunders et al., 2006, p. 117-119).

2.6 Research strategy

The research strategy layer introduces and describes several suitable research methodologies. The overall strategy must be aligned with the overall purpose and research question of the thesis. As previously stated, the purpose of the study is to explain how a capacity analysis and should-cost model can be of use for the supplier selection and contracting process at Northvolt. Due to the characteristics of the purpose and research question, an explanatory approach is most suitable. This is supported by Saunders et al. with the explanation that these types of studies focus on studying a situation or problem in order to explain the relationships between variables (2006, p. 134). In this thesis' case, both research objectives aims to help understand and answer the research question.

Regarding the research strategies listed in Saunders' et al. Research Onion, it was difficult to choose one single research strategy because both qualitative and quantitative data was collected. It is instead more interesting to look inwards in the onion at a mixed method strategy. Mixed method research uses both quantitative and qualitative data collection techniques and analysis procedures to answer the research question. Data collection and analysis can either be done in parallel or sequentially (Saunders et al., 2006, p. 145). As previously stated, in order to answer the research question two research objectives must be completed. For the first research objective, which includes three stages, focus was mainly on quantitative data to answer the North American current and future capacity, corresponding carbon offset and environmental goals for the future, and projected demand of battery cathode foil. For the second research objective, the creation of the should-cost model, focus relied on results from the first research objective and new quantitative data. Lastly, to answer the research question, how the capacity analysis and should-cost model can assist Northvolt in their supplier selection process, qualitative data was needed. The research question, therefore, explains how quantitative results in the research objectives are impactful. As a result, an explanatory sequential mixed method design has been chosen for the thesis. The design can be viewed in figure 2.2 below.

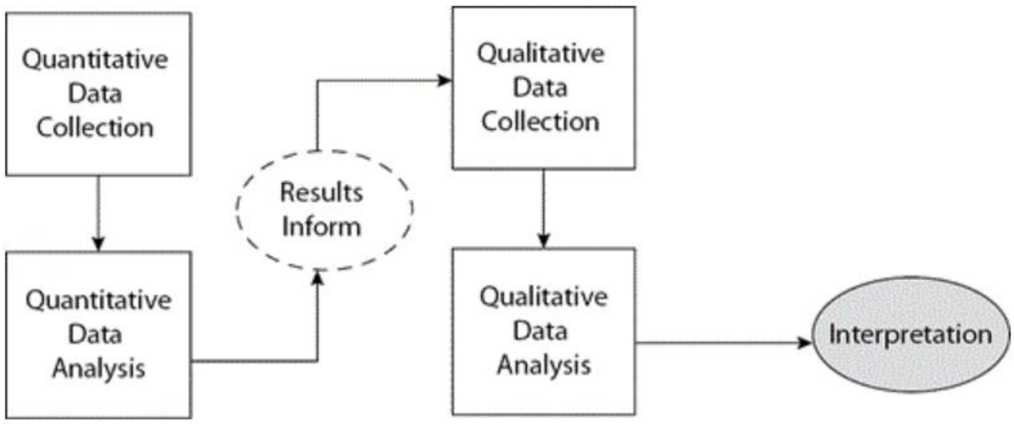

Figure 2.2: Explanatory research design (Watkins et al., 2015)

For an explanatory design, researchers began by gathering and analyzing quantitative data and then collecting and analyzing qualitative data in the second phase. As mentioned in section 2.2, the research philosophy moved from objective to more subjective because the qualitative data (subjective) was gathered and analyzed after the quantitative data (objective). Furthermore, the explanatory factor was useful as it proves how quantitative analysis and results can be used during future use cases that Northvolt will eventually find themselves in (Watkins et al., 2015).

2.7 Research design

The inner layer of the research onion discusses the different data collection and analysis methods to use in regard to the strategy chosen. In other words, how to sample the data, the type of data analysis methods to use and set up the resources needed for the study such as interview questions (Saunders et al., 2006). The research design provided guidance while conducting the study and can be viewed in figure 2.3.

The thesis began with a define and design stage in which the overall plan, structure, design and so forth was decided. However, note that it was possible to return and alter details at this stage. The second stage is where the explanatory sequential research strategy comes in. Here is where the data collection and analysis was conducted. During the quantitative phase, data was collected from Northvolt's databases, secondary data, and interviews and workshops with Northvolt employees. During the qualitative phase, data was collected from interviews and workshops. Lastly, during the final stage is where the final analysis and report writing was conducted.

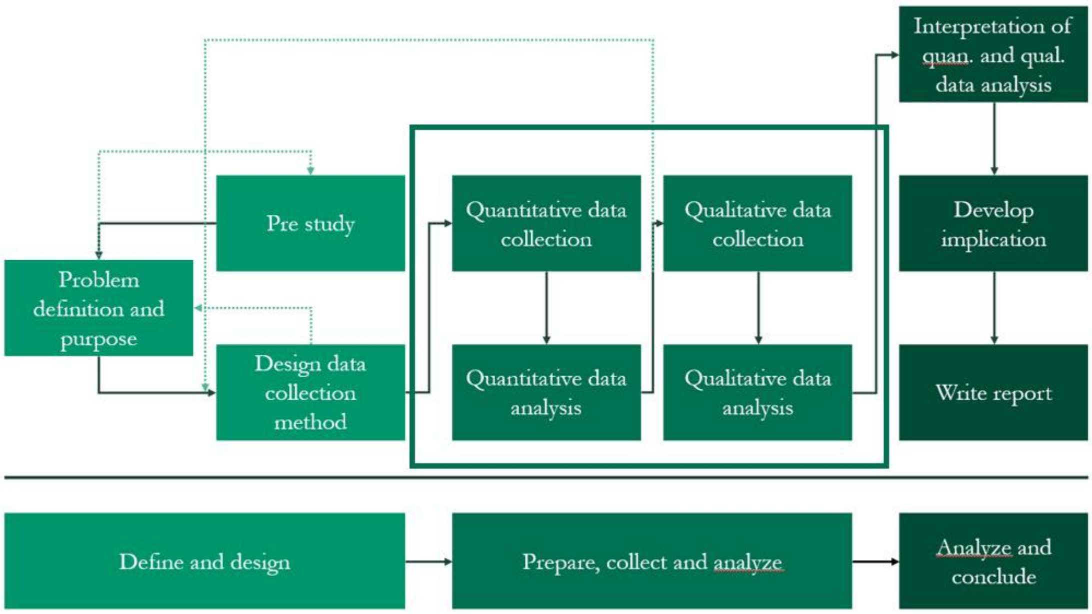

Figure 2.3: The research design (own illustration)

2.7.1 The unit of analysis

A Unit of Analysis (UoA) refers to the phenomenon or entity being studied (Yin, 2014). The UoA in this thesis is Northvolt's procurement system of aluminum foil in North America. This includes analyzing the production process, the value and logistics chain, supplier capacity in each step of the chains and the costs of production for tier one suppliers. An overview over the scope of the capacity analysis and should-cost analysis as well as production outputs and key production processes in the latter stages of production can be viewed in figure 2.4 below.

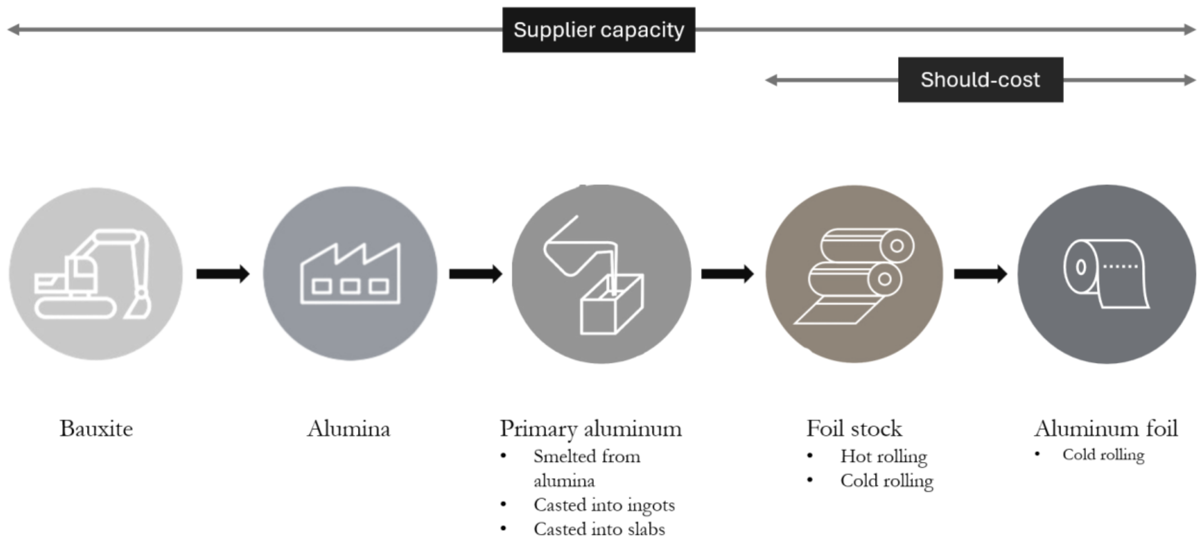

Figure 2.4: Overview of the Unit of Analysis (own illustration)

2.8 Literature review

The literature review is a vital part of the thesis as it builds the foundation on which the results of the analysis relies on. It is also an important part of the project because the authors could quickly gather all relevant information in a short amount of time and chart previous research. This was to ensure that the thesis built new knowledge instead of replicating already conducted research (Björklund et al., 2012). After the literature review had been conducted, a frame of reference was created. This assisted the researchers during data collection and analysis to ensure that the research was conducted within the frame of the thesis.

In this thesis, literature research was done at a high-level in order to gain a broad understanding of the problem. Several themes were investigated, such as the production process of aluminum foil, should-cost analysis, and capacity analysis. After further investigation and review with supervisors at Northvolt and LTH, three key themes were identified: purchasing strategy, the production process of aluminum foil and the purchasing process. These three themes start at a high level and then dive deep into the theory that is needed to fully understand the unit of analysis. To gather information of the three themes mainly LUBsearch, Google Scholar and Springer was used to find articles and books. The search terms used to find relevant information can be viewed in table 2.1 below.

Table 2.1: Used search terms for literature review

Category management	Purchasing strategy
Purchasing structure	Purchasing process
Aluminum foil production	Supplier selection
Strategic purchasing	Should-cost analysis
Strategic cost management	Aluminum production
Bauxite mining	Alumina
Aluminum foil production	Cold rolling
Hot rolling	

2.9 Data collection

After a thorough literature review was conducted and the frame of reference was built, a data collection plan was developed. Since the thesis is based on a mixed-method approach data was collected in two main ways: archival research and interviews and workshops. Archival research was mainly used for quantitative data and interviews and workshops for quantitative and qualitative. The quantitative interviews and workshops were mainly conducted with two experts, one within aluminum foil and one within cost analysis, to gather information regarding specific values for the capacity and should-cost analysis and to ensure that the should-cost was correctly designed. Furthermore, because the research design is an explanatory mixed-method strategy, the quantitative data collection was done before the qualitative. An overview of the data collection methods used can be viewed in table 2.2 below.

Table 2.2: Data collection methods

Data source	Type of data	Collected data
Archival Research	Quantitative	Supplier capacity values, Should-cost cost driver values
Interviews	Quantitative and qualitative	Triangulation for supplier capacity and should-cost cost driver values and structure. Information on how these deliverables is of value to Northvolt

A mixed-method approach was highly relevant for this thesis' case as both qualitative and quantitative data will be necessary to answer the research question. Also, according to Eisenhardt (1989), integrating quantitative and qualitative data can yield highly synergistic outcomes. Quantitative data excels in offering evidence to support hypotheses and revealing previously unrecognized patterns within the data. On the other hand, qualitative data's specialty lies in its capacity to identify and interpret the connections identified through quantitative analysis. These qualities were especially useful here because of the explanatory nature of the problem. Furthermore, by using several data collection methods, the researcher strengthens the validity of the thesis. This is called triangulation (Björklund et al., 2012).

2.9.1 Archival research

Archival research makes use of administrative records and documents that were created for a different purpose than the research question. These records and documents do not have to be of a certain age. It is important to note that the data will not always have exactly what is necessary, or data might be missing data (Saunders et al., 2006, p. 143). In this thesis case, if specific data, for example capacity at a company's facility, could not be found, the researchers planned for what needed to be done, such as estimating the values of the missing. Estimating capacity values was done by, for example, dividing the total global greenhouse gas (GHG) emissions of a company by the GHG emissions intensity to calculate the total volume of aluminum produced.

In this thesis, archival research was first used to gather data on the capacity of the different production outputs for aluminum foil in North America as well as key suppliers in each stage. Data had been gathered from several sources and documents to piece together the capacity for each supplier as well as the total capacity for that stage of the process. Secondly, archival research was applied to gather information regarding data of the present and future demand of battery cathode foil. The sources used varied from company websites to news articles. Thirdly, archival research was used to gather the cost driver values for the should-cost analysis such as energy prices, salaries, and general profit margins. The sources that were used and for which purpose can be viewed in table 2.3 below.

Table 2.3: Archival research data sources

Source	Purpose	Data type
Company annual reports	Capacity analysis	Company current capacity, future capacity plans, revenue, main customer segment
Company sustainability reports	Capacity analysis	GHG emissions in scope 1, 2 and 3, total capacity
News articles	Capacity analysis	Company current capacity, future capacity plans
Market analysis	Capacity analysis	Total capacity for industry, future trends
Company websites	Capacity analysis, Should-cost analysis	Total capacity, GHG emissions in scope 1, 2 and 3.
Northvolt pre-conceived capacity analysis	Should-cost analysis	Example figures of company capacity (tons per year)
Internal investment proposal	Should-cost analysis	Figures on required operators, equipment prices etc.
Public databases	Capacity analysis, Should-cost analysis	Capacity and scope 1, 2, 3 values. Standard values for should-cost model, such as cost of energy and salaries.

Choosing suppliers for capacity analysis

During the archival research, and specifically during data gathering for the capacity analysis, several companies or suppliers in the aluminum foil value chain were chosen as key players to represent one of the output stages of the value chain, such as bauxite distributor, alumina refinery, foil stock producer and so forth. To choose relevant suppliers to include in the analysis, certain criteria had to be set up. The different criteria can be viewed in table 2.4 below.

Table 2.4: Criteria for supplier selection in capacity analysis

Subject	**Criteria**
Capabilities (supplier side)	Ability to: mine bauxite, refine alumina, smelt primary aluminum, roll primary aluminum to coils or foil stock, or roll to 5-20 μm thick aluminum foil
Capabilities (customer side)	Annual production of one or more GWh equivalent of batteries
Operations	Located in North America
Production	Conducts production, not a wholesaler

The players that were included in the analysis were chosen through analysis of how big of an impact they have in their respective stage of output and if Northvolt has expressed any interest in a company. The data gathering started at the top with bauxite mining players. It quickly became clear that companies that mine bauxite also refine it into alumina and lastly smelt it into primary aluminum. Through identification of these companies, several of their customers could be identified through annual reports, news articles and sustainability reports. However, not all companies were found through this method, Max Hedsand and Northvolt's aluminum foil expert recommended some companies to investigate that operate in the final output stages. Finally, all companies that were identified were cross-referenced with the criteria presented above to ensure their relevance to the analysis.

2.9.2 Interviews and workshops

Interviews are a common data collection method and give the researcher access to primary data, in other words, data that was collected for the same purpose as the purpose of the research. There are several forms of interviews, these are structured, semi-structured and unstructured. In a structured interview all questions are chosen beforehand and asked in a chosen order. In a semi-structured interview, the theme of the interview is chosen beforehand, but which questions are asked and in what order are not chosen before and are therefore asked when the interviewer sees it fits. Lastly, in an unstructured interview, questions are not prepared and most often takes place as a phone call. (Björklund & Paulsson, 2012)

In this thesis, interviews have been conducted with a variety of employees at Northvolt. Some of the interviews were semi-structured and some were structured. In total, two workshops were conducted. One with Northvolt's aluminum foil expert and one with expertise in cost analysis. The purpose of the first workshop was to receive input and feedback regarding the structure and content of the capacity analysis and should-cost analysis. The purpose of the second workshop was to verify the structure, design, and calculations of the should-cost model. These workshops were semi-structured in nature because the overall theme was decided beforehand, but no all questions and discussion points were decided prior. The structured interviews were conducted to gather qualitative data on why and how these two deliverables are of value to Northvolt's supplier selection and contracting processes in North America and for future operations. These interviews were conducted with category managers at Northvolt from two different purchasing units. The different interviews that were conducted can be viewed in table 2.5 below.

Table 2.5: List of interviewees

Date	Interviewee	Title	Purpose	Structure
2024-03-04	Aluminum foil expert	Aluminum foil expert	Input and feedback on initial structure of capacity and should-cost analysis	Semi-structured
2024-04-04	Aluminum foil expert and category manager 2	Aluminum foil expert and category manager for foils	Workshop on the structure of the should-cost analysis	Semi-structured
2024-04-19	Purchasing director	Purchasing director chemicals and components	Contribution to supplier selection and contracting	Structured
2024-04-22	Category manager 1	Category manager for electrical segment	Contribution to supplier selection and contracting	Structured
2024-04-22	Category manager 2	Category manager for separators	Contribution to supplier selection and contracting	Structured
2024-04-22	Category manager 3	Category manager for chemicals	Contribution to supplier selection and contracting	Structured
2024-04-22	Cost analysis expert	Senior manager purchasing	Workshop – should-cost validation	Semi-structured
2024-04-24	Category manager 4	Category manager for foils	Contribution to supplier selection and contracting	Structured

2.10 Data presentation and analysis

Data analysis was an important part of this thesis, and it is therefore crucial that it was planned and structured correctly. Saunders et al. (2006, p.420) describes how both quantitative and qualitative data can be analyzed. For the quantitative data an explanatory analysis approach can be used. This approach emphasizes the use of figures and tables to clearly present and explain the data collected. Moreover, the data can be presented in several ways by for example plotting data according to specific values, highest and lowest values, trends over time, proportions, and distributions. Plotting the data according to these criteria assists the researchers in finding trends, comparing values, finding conjunctions, interdependencies, relationships and so forth. (Saunders, et al., 2006)

Saunders et al. (2006, p. 487) continues to explain several approaches to qualitative data analysis. One approach is using a theoretical or descriptive framework which means using existing theory to help organize and direct the data analysis. This is done by identifying key variables, components, themes, and issues surrounding the research to create the framework and build the analysis around the topics found. This approach can be combined with the pattern matching procedure of explanation building introduced by Robert Yin which is relevant for explanatory studies (Saunders, et al., 2006, p. 490). This procedure attempts to build an explanation while collecting and analyzing data, rather than testing a predicted explanation, which is what this study was designed to do. This procedure follows six steps that, in general, follow the same structure as the previously stated research strategy in section 2.3. (Saunders, et al., 2006)

In this thesis analysis was conducted on both quantitative and qualitative data. To ensure the quantitative analysis can be conducted effectively all the data collected for this thesis has been clearly presented with figures and tables in chapter 4. The first quantitative analysis was conducted on the capacity analysis. This was done by comparing values to find relationships. For example, comparing capacity values from different productions stages of aluminum foil to find bottlenecks, or comparing capacity values in the final stage with demand values to analyze differences. Secondly, the should-cost was mainly analyzed from a utilization perspective, in other words how the model can be used outside of the proposed use cases. One of the main analysis points regarding the should-cost was the realization that a weight analysis could be conducted. After all cost drivers were identified and decided we realized that comparing each cost driver to the final should-cost could result in interesting insights. Therefore, each standard value for each cost driver in the model was increased by 10 percent to observe the increase, in percentage, of the should-cost. A table of the results was created in presented in chapter 4.

The main analyzing point was the final point in which the contribution these two deliverables have towards Northvolt supplier selection and contracting processes. This data was qualitative and was conducted according to the theory presented above. The analysis was directed through the theoretical framework which is presented in chapter 3 to ensure that the analysis was relevant to the topic of the thesis. Furthermore, the qualitative analysis was conducted after the quantitative data collection and analysis to explain and answer the research question. This is because the thesis follows an explanatory approach.

2.11 Research quality

Saunders et al. (2006) continues to explain that to reduce the risk of getting the answers to the research questions wrong, attention must be paid to two important themes: reliability and validity.

2.11.1 Reliability

The first theme regards to which extent the data collection techniques or analysis procedures have been able to yield consistent findings. To assess these three questions can be asked (Saunders, et al., 2006):

1. Will the measures yield the same results on other occasions?
2. Will similar observations be reached by other observers?
3. Is there transparency in how sense was made from the raw data?

The main threat regarding reliability is, firstly, subject or participant error. This is mostly relevant for surveys and interviews and can be avoided by not creating too complicated surveys and choosing a neutral time to conduct the interview. In this thesis' case, surveys were not used as a data collection source and interview and workshops were conducted during reasonable hours when the interviewee is alert. Secondly, subject bias is important to watch out for. In the case of this thesis, the questions asked in interviews did not incite opportunities for bias. Also, this threat is most often seen at firms with an authoritarian management style, which Northvolt does not have. The third threat regards observer bias. In this thesis several actions were taken to minimize this risk. The questions asked during the qualitative interviews were the same for each interviewee, several category managers were interviewed to gather a more comprehensive picture of the contribution of the deliverables and lastly comparing answers with theory to triangulate the answers. (Saunders, et al., 2006)

2.11.2 Validity

The second theme is concerned with if the finding is truly what they appear to describe (Saunders, et al., 2006). Saunders continues to explain several threats that can harm the validity of the research. These include history, testing, instrumentation, mortality, maturation, ambiguity about casual direction. Firstly, history regards gathering data that is not time relevant. In this case, the data gathered for the capacity analysis was always gathered from the latest annual report, news articles and so forth. Secondly, testing refers to data being tampered with by the method of testing. This thesis did not conduct tests. Thirdly, instrumentation refers to changes in measurement and this was not pertinent in our thesis. Fourthly, mortality regards that participants exit from the study and was also not pertinent to our case. The fifth threat refers to changes to the participants over time and was not relevant. Lastly, ambiguity refers to variables being co-dependent on other variables. To ensure this does not harm the validity, the researchers can for example lean on theoretical frameworks and strong theoretical grounding to triangulate the data gathered which was the used method for this thesis. (Saunders, et al., 2006)

External validity

Saunders et al. (2006) also describes external validity which is to what extent the research is generalizable, in other words how applicable it is to other research settings. In this thesis case, only one company is researched upon and the deliverables are catered to their specific situation and needs. The analyses and models created are therefore not meant to be generalizable and the thesis does not claim them to be. However, the thesis tries to prove the use of a general should-cost model in the day-to-day work of purchasers by presenting the contributions the model can have. Also, the process of should-cost modelling that is presented in section 3.3.5 has not been created specifically for Northvolt's use and is meant to be applicable to any situation. To ensure that the process is general, it was created by merging and improved two other processes and validated together with an expert in cost analysis.

3 Literature review

This chapter covers relevant theory and literature findings on topics that are of importance to the thesis. The chapter is divided into three themes in order to clearly explain the context needed to understand and draw conclusions in the latter part of the thesis. Each theme starts by explaining the foundation behind what the theme aims to explain. For example, to clearly explain the should-cost analysis, we must first describe van Weele's purchasing process which is described in detail in his book Purchasing and Supply Chain Management (2022). The first theme's goal is to explain the category management purchasing strategy. The second theme aims at explaining the production process of aluminum foil. The third theme's aim is to explain and discuss what the should-cost analysis is and what it is used for. The learnings are then synthesized into a framework that will lay the foundation for the result and analysis phase of the thesis. In figure 3.1, the topics of the theoretical framework are illustrated, along with the corresponding components of each researched theme.

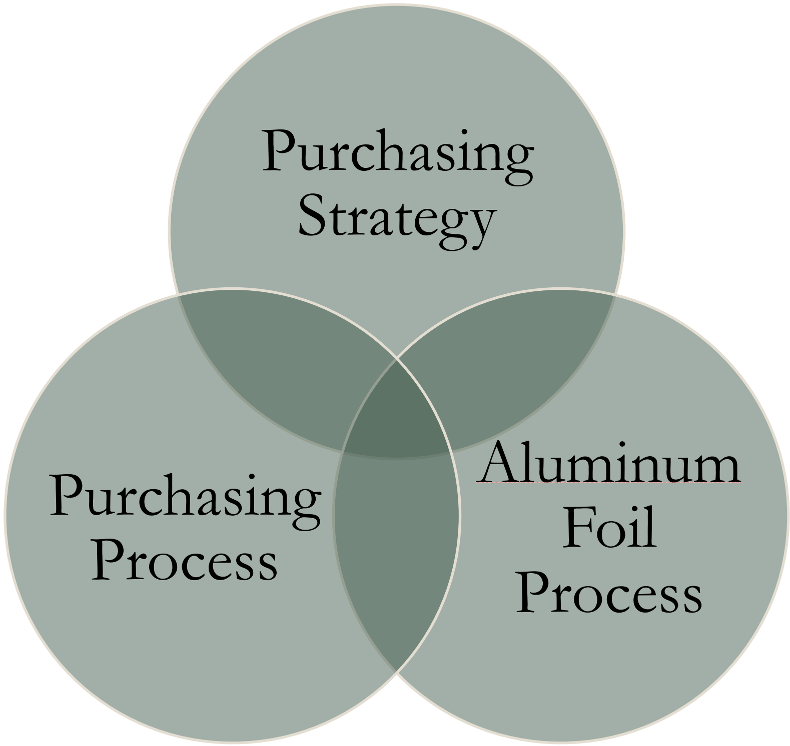

Figure 3.1: Illustration of theoretical framework to support thesis (own illustration)

3.4 Purchasing strategy

This section explores key frameworks for structuring a company's purchasing strategy, emphasizing the importance of aligning these strategies with organizational goals. It discusses decentralized and centralized purchasing, the hybrid model, and the role of cross-functional sourcing teams. Decentralized purchasing allows individual units autonomy, whereas centralized purchasing consolidates decisions at a corporate level for uniformity and leverage. The hybrid model combines these approaches to optimize benefits, and cross-functional teams bring diverse expertise to the procurement process. The choice among these structures is influenced by factors such as product commonality, geographical distribution, supply market structure, and required expertise. This analysis is crucial for determining the most effective purchasing strategy to enhance organizational efficiency and cost savings. Lastly, the topic of category management is researched, with insight to its benefits and considerations for successful implementation.

3.4.1 Purchasing structure

This section outlines the conventional frameworks for organizing a company's purchasing strategy, highlighting key considerations for selecting the most suitable approach. The primary structures discussed include decentralized purchasing, centralized purchasing, a hybrid model, and the integration of cross-functional sourcing teams.

Decentralized purchasing

In a decentralized structure, individual business units are responsible for their own purchasing activities and financial outcomes. This model is particularly effective for units that procure distinct items requiring specialized management approaches, unique from those of other units. While this structure fosters autonomy and can be closely aligned with specific unit needs, it may limit the organization's ability to achieve economies of scale due to fragmented purchasing efforts (van Weele, 2022, p. 325). A decentralized structure allows the procurement decisions to be made closer to the operational level, which enhances the responsiveness to local needs, preferences, or market conditions (Richter et al., 2019). A major concern with this structure, is the risk of unstandardized procurement processes, meaning that the applied strategies regarding procurement might differ across the organization, allowing for inconsistencies in quality, delivery and cost (Richter et al., 2019).

Centralized purchasing

Under a centralized framework, a singular corporate-level team oversees all significant purchasing decisions, encompassing both strategic and tactical aspects across all business units. This approach ensures uniformity and compliance with overarching corporate policies and supplier selections. Although it may restrict the purchasing flexibility of individual units, the centralized structure enables better negotiation leverage, potentially leading to improved pricing and service terms due to coordinated sourcing efforts (van Weele, 2022, p. 325-326). In more complex and uncertain environments, a centralized purchasing structure tends to be more effective in managing risks and ensuring supply consistency in terms of quantity and quality (Richter et al., 2019).

Hybrid structure

The hybrid model seeks to amalgamate the strengths of both decentralized and centralized structures to optimize benefits. It is particularly applicable in scenarios where business units have overlapping supply needs, allowing for coordinated purchasing to enhance terms and conditions. Nevertheless, units retain the autonomy to manage unique supplies relevant to their specific operations, blending centralized coordination with decentralized responsiveness (van Weele, 2022, p. 326).

Cross-functional sourcing teams

As the name suggests, this strategy aims to integrate cross-functional cooperation regarding procurement. This could for example mean that perspectives from finance, marketing and operations are included in the relevant purchasing decisions. Incorporating cross-functional teams into purchasing strategies brings together diverse expertise and perspectives, fostering a collaborative approach to sourcing. These teams typically operate within the context of the chosen structural model (decentralized, centralized, or hybrid) and contribute to a more holistic and integrated procurement process, aligning purchasing activities with broader organizational goals. Incorporating category management into cross-functional sourcing teams enhances the strategic procurement process by leveraging diverse expertise and collaborative efforts across different departments (van Weele, 2022, p 105).

3.4.2 Criteria for strategic fit in purchasing structure

According to van Weele, the identification of which purchasing structure to adopt is often based on the following criteria:

The commonality of the product
The more standardization of the acquired product or service the greater impact of centralized purchasing. In this structure, the centralized purchasing unit can achieve economies of scale, which is why sourcing raw-material and packaging materials are often located at one corporate location.

The geographical location
The geographical locations of the business will affect coordination efforts considerably. If the company operates in many different countries or regions, the trading and business practices will differ between the business units, prohibiting standardization of procurement strategies (Van Weele, p. 275).

The structure of the supply market
The structure of the supply market, meaning the number and capacity of relevant suppliers, will impact the purchasing strategy of the buying party. If one or a few suppliers correspond to most of the capacity in the relevant region, the power is heavily shifted towards the supplying unit, whereas the buyer logically adopts a centralized purchasing approach to arrange for better negotiation position. The other way around for scenarios where the capacity is distributed over a large amount of supplier (Van Weele, 2022).

Certain expertise
In some scenarios, certain expertise is required to effectively acquire supply to a sustainable extent. This is applied in markets where prices are fluctuated and difficult to predict, whereas it is suitable to adopt a centralized purchasing unit to manage the organizational procurement. For strategic and high-risk categories of suppliers, central oversight is often crucial, while basic operational or less critical categories are often more suitable for a decentralized structure (Richter, et al., 2019).

As described, all structures serve their purposes, where the criteria above should be carefully analyzed before deciding which to apply.

3.4.3 Category management

Category management is a management philosophy which aims to link the purchasing function and organizational goals. It refers to the strategic approach in procurement and supply chain management where goods and services are categorized into distinct groups. This is done to more effectively manage these categories as strategic business units to optimize value, enhance efficiency and achieve cost savings. It involves a comprehensive analysis of categories to identify opportunities for consolidation, standardize requirements, and leverage spend across the organization, aiming for a more organized and strategic procurement process. To ensure efficiency in the categorization of products it is vital to receive synergies within factors such as functionality in the organization, potential to implement cross-functional teamwork within the category, and that the categorization reflects how supplier and products are organized in the market. If done successfully, the implementation of category management averages cost-savings of 10-20 percent per category of spend. (Arruda et al, 2019). According to van Weele, the category sourcing strategy should address the following topics: single versus multiple sourcing, global vs. local sourcing, partnership or competitive relationship, buying on contract or buying on spot basis, and price agreement vs performance agreement (van Weele, 20222).

Single vs multiple sourcing

Whether to purchase the product from one supplier or from multiple suppliers is dependent on the importance of the product along with the buying company's risk preferences. Single sourcing strategies corresponds to a higher risk of supply disruptions when compared to multiple sourcing, despite potentially providing cost benefits (Manuj et al, 2008).

Global vs local sourcing

In terms of deciding whether to source from local or global suppliers, the choice is an equation of multiple variables. These are the characteristics of the product, meaning the complexity or standardization, the sensitivity of lead-times and reliability. Van Weele argues that for high-tech specific items, high flexibility and precision are desirable in terms of delivery, therefore local sourcing is favorable. On the other hand, for standardized bulk products, where price differences occur on a geographical plane and the product can be purchased in large volumes to attain economies of scale, global sourcing is preferred (van Weele, 2022, p. 116).

Applying a global supply chain increases the complexity of managing risks as there are more environments and thus, more sources of risk to consider. For products which are similar or identical in all parts of the world, it is often advantageous to acquire the set of suppliers in close proximity to the manufacturing facilities – to maintain a certain degree of consistency in terms of quality and performance. The main argument to establish a global supply chain is the potential to acquire low-cost supply in terms of purchasing price by sourcing from countries with cheaper production. However, this must be weighed against important aspects, such as lead-times due to transportation, quality, and costs due to further distance of distribution. If quick response times and reliability is prioritized, local supply is often preferable (Norrman et al, 2023). Another aspect in favor of local sourcing, are the environmental benefits it entails. The distribution of goods and services results in less carbon dioxide and other harmful offsets the shorter the transportation route is (Keteres, 2023).

Partnership vs competitive relationship

By establishing a partnership relationship, the two parties require willingness to the sharing of sensitive data and long-lasting contracted agreements. Competitive relationships are based on regular analysis of the propositions of previously approved suppliers and basing the purchasing volume of each on the potential value in the offer. This strategy is often preferred when sourcing commodities where products are purchased in large volumes and many potential suppliers are available (van Weele, 2022). By engaging in close collaborative inter-company relationships both parties are able to increase effectiveness, efficiency, and market-position enhancement (Min et al, 2005).

Buying on contract vs buying on spot basis

Whether to cover the full volume of supply by a contract-agreement or to buy a certain quantity based on the spot-price is largely based on the preference towards flexibility and security. By contracting, the supply is guaranteed at an agreed volume and price, however the buying party might suffer from market fluctuations (van Weele, 2022, p. 116).

Price agreement vs performance agreement

This regards the specific agreements conducted in the contract. Either the price is the only parameter of interest, or factors such as delivery reliability, services, guarantees and more are included as well, referred to as Service Level Agreements. For standardized products, pricy-only agreements could be sufficient (van Weele, 2022, p. 117).

Direct category

Direct categories, in contrast to indirect categories, refers to all purchased materials that are directly integrated into the value proposition of the company. Since the selling price of the finished product is largely correlated to the purchasing price of the corresponding direct materials, the companies are specifically on the lookout for new opportunities to decrease this cost. The greater the commonality of the purchased products and services required by the business units, the more benefits can be obtained from a centralized or coordinated approach. This explains why the procurement of raw material and packaging materials in large companies is often concentrated at one corporate location (van Weele, 2014). In table 3.1 below is a summary of the different aspects and topics considered in this section.

Table 3.1: Summary of category management section

Category Management Aspect	**Description**
Philosophy	Aims to link the purchasing function with organizational goals.
Strategy Approach	Goods and services are categorized into distinct groups to manage them as strategic business units.
Analysis	Comprehensive analysis to identify opportunities for consolidation, standardize requirements, and leverage spend.
Synergies	Vital to achieve within functionality, cross-functional teamwork, and market organization reflection.
Cost-Savings	Implementation can lead to 10-20% cost savings per category of spend.
Category Management Topic	
Single vs multiple sourcing	Depends on product importance and the company's risk preferences. Single sourcing has higher risk but potential cost benefits.
Global vs local sourcing	Choice between local or global suppliers depends on product characteristics, lead times, reliability, cost- and risk considerations.

Partnership vs competitive relationship	Partnership involves sharing of sensitive data and long-lasting agreements, while competitive relationships focus on value from approved suppliers.
Buying on contract vs spot basis	Decision between securing supply via contracts or buying based on spot prices, influenced by preference for flexibility or security.
Price vs performance agreement	Contracts can focus solely on price or include performance aspects like delivery reliability and services (Service Level Agreements).

3.5 Production process of aluminum foil

This section will focus on the production process of aluminum foil. The entire value chain from mining to packaging will be described as well as the environmental impact and logistics chain of aluminum and aluminum foil in North America. The process is graphically summarized in figure 3.2 below.

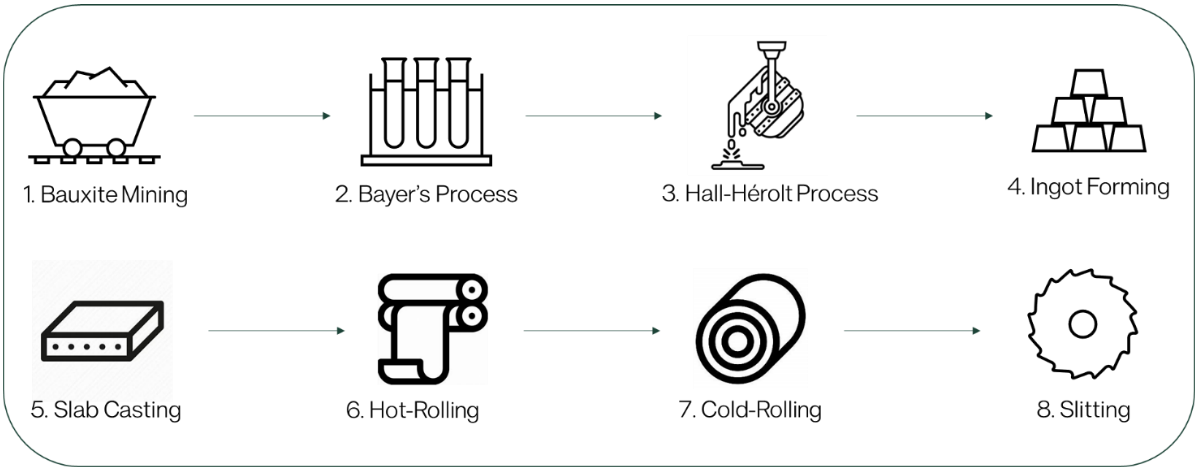

Figure 3.2: The aluminum foil production process (own illustration)

3.5.1 Bauxite mining

The primary raw material used in the production of aluminum is bauxite-ore, which is rich in aluminum-trihydrate ($Al(OH)_3$). Apart from hydrated aluminum oxides, bauxite ore contains numerous other metals and minerals. The bauxite rock formations are formed due to long periods of exposure of tropical or very wet temperate conditions, which is why most mines harvesting bauxite are located in tropical regions, such as Brazil, Jamaica, Guyana, and Australia. On most occasions, bauxite is found close to the surface, with only one or two meters of overburden (Donoghue et al., 2014).

3.5.2 Bayer's process

The most common process of refining bauxite-ore to alumina (aluminum-oxide or AL_2O_3) is called Bayer's process. This process largely contributed to reducing the cost of alumina in industrial production (Ratvik et al., 2021). In this process, bauxite is mixed with a strong alkaline solution, typically sodium hydroxide. This mixture is then heated and subsequently cooled before being filtered. The purpose of this process is to separate the aluminum-containing components from impurities present in the ore (Hind et al., 1998).

3.5.3 The Hall-Héroult process

In the third step of production, the alumina is subjected to an electrolytic reduction known as the Hall-Héroult process. In this process the alumina is split into its core components, aluminum and oxide. Here, alumina is dissolved in a molten cryolite bath within a large carbon or graphite-lined steel container called a "pot." An electric current is passed through the molten mixture, causing the alumina to decompose and deposit pure aluminum at the bottom of the pot. The aluminum is then siphoned off and cast into blocks known as ingots. This process' output is known as primary aluminum, which means that the aluminum was made from the raw material bauxite. There is also secondary aluminum, which is made from recycled aluminum (Haupin, 1995).

3.5.4 Slab casting

The latter part of the production process is split into four main parts: slab casting, hot rolling, cold rolling and slitting and packaging. Slab casting is a simple step in which several aluminum ingots are melted and cast into large 10–25-ton slabs. These slabs are then further processed by for example hot rolling (Barten, 2002).

3.5.5 Hot Rolling

There are three different hot rolling methods that are used today. All these methods have their respective advantages and disadvantages in terms of quality, productivity, energy usage, labor intensity and investment requirements (Barten, 2002). In general, the heated aluminum is passed through rollers which reduces the thickness. This is done several times with large force to elongate and thin the aluminum slab into a thickness varying from 3-20 mm. When hot rolling, the structure of the aluminum is converted to a wrought structure with finer grains and enhanced ductility, which enables the metal to be worked on further without it cracking or breaking. Typical temperatures for hot rolling aluminum is around 450ºC (Kalpakjian et al., 2023).

3.5.6 Cold Rolling

In contrast to hot rolling, cold rolling is carried our near room temperature and aims at producing sheets and strips with a better surface finish, dimensional tolerance, and enhanced mechanical properties. In order to increase productivity, two or more layers are packed together, which is a process referred to as pack rolling (Kalpakjian et al., 2023, p. 373). In production of aluminum foil, the working sheets are pack rolled in two layers. This results in one of the surfaces being in contact with foil, and the other surface in contact with the roll. The foil-to-foil side has a matte and satin finish, whereas the foil-to-roll side is shiny and bright. Despite the name, cold rolling, the sheet is heated to approximately 100°C due to the amount of friction and deformation occurring in the process during each pass of the rolls. Therefore, a large amount of coolant must be applied to the rolls to maintain a thermal equilibrium. The cold rolling process typically involves multiple passes through the rolling mill, with three to four passes being common. Between each pass, the aluminum coils are allowed to cool back to room temperature, a process that can take several hours. This cooling phase is crucial for maintaining the material's integrity and workability. As the aluminum passes through the rollers, it undergoes work hardening, increasing its strength but also making it more brittle. To counteract this, the aluminum may undergo intermediate annealing treatments to relieve internal stresses and restore ductility, allowing for further thickness reduction in subsequent rolling passes without the risk of cracking (Barten, 2002).

There are several companies that supply machines for the later processes of producing aluminum foil, for example Achenbach and Mino. Achenbach supplies several different machines depending on what stages of the process the producer wants to be a part of. For the cold rolling part of the process, the supplier can purchase an Achenbach Optimill Foil Rolling Mill which can roll the aluminum to a thickness of 0,0045 mm if desired and roll into coils with a weight of 16 000 kg. There are different models of this machine depending on the thickness and specialization of the final product (Achenbach, n.d.). Secondly, the company named MINO sells machines that can cold roll aluminum foil. They offer several models depending on factors such as the desired thickness of the aluminum. One of the models they offer is a specialized battery foil mill, which is optimized for producing aluminum foil for batteries, or in other words cathode foil. This allows for foil production with the correct properties, such as having a thickness between 10 and 12 μm (MINO, n.d).

3.5.7 Slitting

The final step of the production line is to slit the final product. Slitting is done with highly accurate slitting geometries so that the foil can be customized to the desired width of the customer (Barten, 2002). This can be done with Achenbach's Optifoil Rewinder machine which slits and trims the aluminum foil to the customer's desired width (Achenbach, n.d.).

Finishing the aluminum foil production process, the foil is rolled and packaged into large wooden boxes and shipped to customers.

3.5.8 Environmental perspective on aluminum foil production

Aluminum, the second most prevalently used metal today, is known for its flexibility, strength, and lightweight properties, making it indispensable across various industries. However, its production process, particularly from bauxite to aluminum (as outlined in steps 1-3 in figure 3.2), is energy-intensive and contributes significantly to GHG emissions, accounting for approximately one percent of annual global GHG outputs. The development of sustainable aluminum foil production originates from three main trends. These are recycling material, advancement in technology and the use of renewable energy (Wang, 2022). However, firstly the global greenhouse gas protocol and scopes must be explained.

The Global Greenhouse Gas Protocol

The Global Greenhouse Gas Protocol is a globally recognized framework designed to understand, quantify, and manage greenhouse gas emissions. Developed through a partnership between the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), it serves as the cornerstone for government and business leaders aiming to take comprehensive action against climate change. By offering a standardized approach to greenhouse gas measurement and management, the GHG Protocol facilitates both private and public sector efforts in tracking and reducing emissions (WBCSD, 2004).

Central to the GHG Protocol is the categorization of emissions into three distinct scopes, each encompassing different sources of emissions across an organization's operations and its broader value chain. Scope 1 emissions are direct emissions from sources that are owned or controlled by the reporting entity, such as emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc. These emissions are the most immediate and often the first area where organizations look to reduce their carbon footprint (WBCSD, 2004).

Scope 2 emissions capture indirect emissions from the generation of purchased electricity, steam, heating, and cooling that the reporting organization consumes. Although these emissions occur at the site of the energy generation, they are attributed to the organization that purchases and uses the energy. Addressing scope 2 emissions often involves strategies like shifting to renewable energy sources or enhancing energy efficiency (WBCSD, 2004).

Scope 3 emissions, the most comprehensive and often the largest source of an organization's greenhouse gas emissions, include all other indirect emissions that occur in the company's value chain. This can range from emissions associated with business travel, procurement, and waste disposal to the use and end-of-life treatment of sold products. Due to their extensive nature, scope 3 emissions present both a significant challenge and a substantial opportunity for organizations seeking to manage their environmental impact comprehensively (WBCSD, 2004).

By categorizing emissions into these scopes, the GHG Protocol provides organizations with a clear framework for identifying and addressing the various sources of emissions within their operations and value chains. This comprehensive approach not only aids in the effective management of greenhouse gases but also supports organizations in contributing to global efforts towards mitigating climate change (WBCSD, 2004).

Recycling

Aluminum can be recycled an unlimited number of times without damaging its functionality. This is a decisive factor in the environmental impact of aluminum production, where the amount of recycled material in the mix plays a substantial role in the carbon footprint. In the life cycle assessment report "The Environmental Footprint of Semi-Fabricated Aluminum Products in North America" (Wang, 2022), the production and usage of primary- and semi-fabricated aluminum products is analyzed. It was discovered that it requires roughly 15 times more energy to produce primary aluminum than semi-fabricated aluminum. As a result, a one percent increase of primary aluminum in the mixture corresponds to a 117 kg increase of CO_2 equivalents when producing one ton of aluminum products cradle-to-gate. However, the ability to access recycled aluminum is drastically limited due to the long lifetime in use of aluminum products and the lack of proper infrastructure to efficiently and effectively separate different relevant materials and alloys (Wang, 2022).

Another concern in this field is the purity requirements when aluminum is applied to high-technology fields such as semi-conduction and electronics. For these applications, the purity level needs to exceed 99,9%, which is difficult to achieve even when producing primary aluminum (Curtolo et al, 2021). As the aluminum is recycled the aggregated amount of unwanted content increases, making the material less suitable for high-technology implementations. Consequently, industries that have exacting standards for purity frequently prefer to utilize primary aluminum, as it offers a more reliable guarantee of meeting these high purity specifications (Watson, 2022).

Advancement in technology

The aggregated carbon footprint of the early steps in the value chain is significantly larger than the process of remelting recycled aluminum. The process of converting alumina into aluminum is the significant source of energy demand in the aluminum production process. In 2016 this step in the value chain represented roughly 75 percent of the total carbon footprint of the aluminum production in North America. However, it is important to consider the improvements made in this sector. In North America, the carbon intensity of producing primary aluminum almost halved between 1991 and 2016. This is mostly due to improvements in the smelting technology, where old mechanisms have gradually been replaced by newer and more energy efficient technology in the electrolysis process (Wang, 2022).

Renewable energy sources

Another factor which explains the advancements in aluminum production, especially in North America, is the share of renewable electricity increasing while the energy produced by coal is decreasing. In North America the share of renewable energy for primary aluminum smelting has increased by almost 20 percentage points, from 62 percent to 80 percent. The aluminum industry is quite unique in its ability to track the energy footprint with high precision, which is due to the consumption of energy being stable (Wang, 2022).

Aluminum foil specifics

For companies operating downstream in the value chain of aluminum foil, the sourcing of aluminum is crucial to the overall carbon footprint of the end-product, referring to the scope 2 emissions. In Wang's report, where 35% of the total aluminum foil production participated, it is revealed that approximately three quarters of the ingots used for the foil production were recycled and originated from either pre-consumer scrap or post-consumer scrap. The process steps applied to turn aluminum ingots into foil, more specifically rolling, require an additional kilogram of carbon footprint per kilogram of foil produced. In total, according to Wang, it takes 4,6 kg of CO_2 equivalents to produce the average kg of aluminum foil in North America (Wang, 2022).

3.5.9 Value chain of North American aluminum foil

According to Wang's report (2022), most of the aluminum consumption in North America originates from domestic production, where more than 80 percent has been refined in the U.S or in Canada. The next importer is from Russia at around 10 percent. Moreover, since bauxite ore is naturally non-existent in North America, imports from other countries are a vital part of the domestic production of aluminum. Where in the value chain the imports are being made varies, most imports consist of either bauxite ore or alumina. Bauxite is usually imported from Jamaica, Brazil or Guinea, which aggregated represents 91 percent of the total imports in this category. Regarding the production of alumina, nearly half is produced domestically, while the rest is imported. The sources of imported alumina are Australia, Suriname, Brazil and Jamaica (Wang, 2022).

Because of the long and complex production process of aluminum, there is no company that is totally vertically integrated. The production process is split up most often into two to three parts. The mining of bauxite, refinement of alumina and primary aluminum is usually done by the same company. In North America, Rio Tinto, Alcoa and Hydro are among the largest that operate in the market. These companies all have operations in the three first production stages, bauxite mining, alumina refinement and production of primary aluminum (Rio Tinto, n.d.; Alcoa, n.d.; Hydro, n.d.). Moreover, companies such as Kaiser Aluminum manufacture semi-fabricated products which include aluminum sheets and plates through various methods (Kaiser Aluminum, n.d.). Lastly, the final two production steps, rolling and slitting, are conducted by, for example, Novelis and Amcor, which are two of the largest manufacturers in the US (Al Circle, 2023).

The aluminum foil production process is a complex process and includes several outputs which can be used for other purposes. The outputs of each process are visualized in figure 3.3 below.

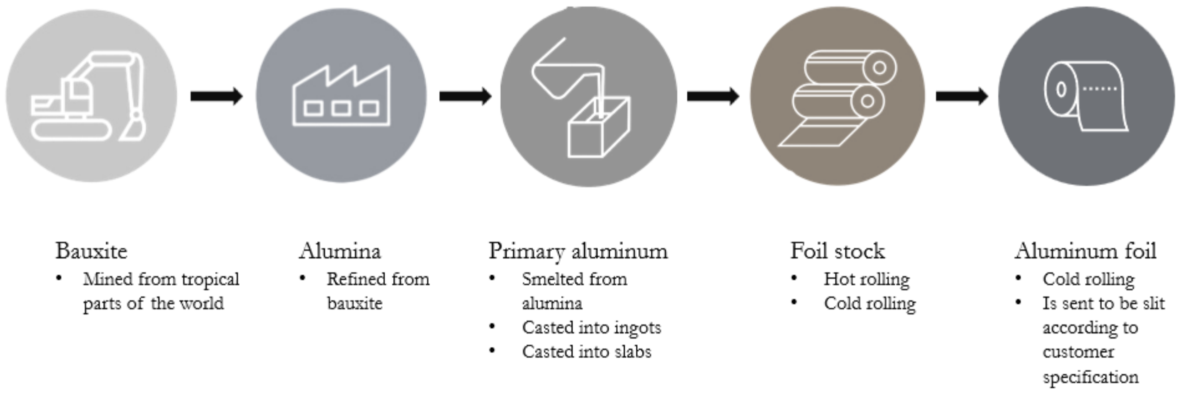

Figure 3.3: Outputs from each part of the value chain (own illustration)

3.6 Purchasing process

The goal of the third theme is to explain and discuss the should-cost analysis tool. In order to do so, we must first start at a high level by explaining the purchasing process and strategic purchasing. One of the stages in the purchasing process is supplier selection, and how this process can evolve together with processes from strategic purchasing. Furthermore, from strategic purchases comes strategic cost management (SCM). This can be used in the final stages of choosing a supplier. An example of one of the tools derived from SCM is the should-cost analysis.

3.6.1 The purchasing process

In order to understand the purpose of the thesis, the basics of the purchasing process must be explained. The purchasing process was introduced by van Weele (2022) and describes a linear model for how the purchasing process in general looks like. The model includes six steps which start with three tactical and ends with three operational. The three tactical steps include define specification, supplier selection and contract and negotiation; while the three operational steps include ordering, expediting and evaluation. Van Weele (2022) explains that the model has a multitude of purposes that are important for companies purchasing and overall business. These purpose include that the purchase is aligned with the businesses overall needs and requirements, that responsibilities for the different steps are clearly defined, that costs are optimized, that supply risk is minimized, that strong supplier relationships are built, and because the model is clearly divided into tactical and operational steps it is easier to combine skills and different types of knowledge in order to arrive at an optimal solution (van Weele, 2022).

3.6.2 Strategic purchasing

As a complement to the purchasing process, van Weele also discusses strategic purchasing which delves deeper into the strategic rather than the tactical. Strategic purchasing emphasizes integrating the purchasing and supply function to other domains in the organization, in other words it aligns the purchasing divisions work with the overall strategy and objectives of the firm (van Weele, 2022). Strategic purchasing has become more important in organizations today and is a vital part in enabling the competitive advantage in the firm. Traditionally these questions have been viewed as back-office operations, but now have started to move into the C-suite in order to add value to the corporate strategy (Landale et al., 2017). The decision of what function to outsource and what to keep in-house has become a core part of corporate strategic sourcing. The following also entails decisions on how to select suppliers and how to structure the supplier-buyer partnership. By developing a successful strategic purchasing framework to work by, the firm can effectively leverage the total spend, optimize the supply base and minimize total supply chain cost and maximize the value of procured products and services. Strategic sourcing is seen as a tool within category management that is focused on leverage volume to drive down costs (Landale et al., 2017).

The purchasing excellence framework

Regarding strategic purchasing, van Weele describes a model developed by Monczka at Michigan State University together with several large manufacturing companies. Their goal was to build a framework describing the process of reaching "strategic purchasing excellence". The model can be viewed in figure 3.4 below. It includes eight processes that are vital to implement when striving for strategic purchasing excellence. In line with the definition of strategic purchasing above, this model does not consider any of the tactical or operational steps discussed by van Weele, it instead discusses how purchasing can become integrated, aligned and a global part of the firm's strategy. The model's aim is to create a long-term purchasing policy, in contrary to the purchasing process which aims at describing the process of an actual purchase (van Weele, 2014).

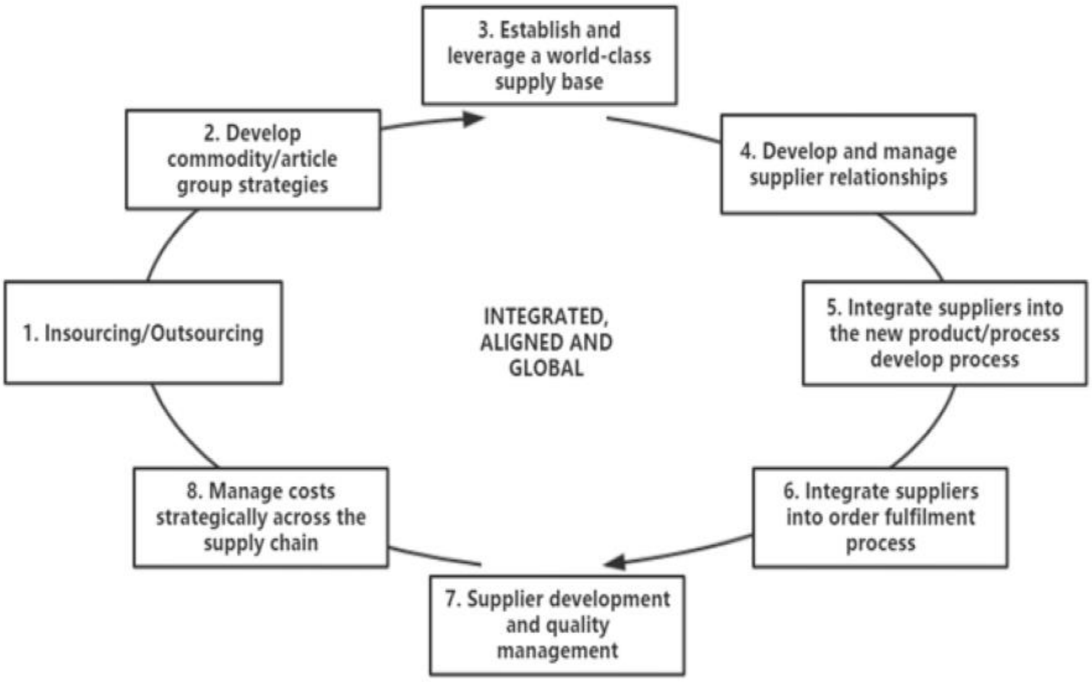

Figure 3.4: The purchasing excellence model (Bäckstrand et al., 2019)

Van Weele presents the framework with the following eight processes: Insourcing/outsourcing, develop commodity/article group strategies, establish and leverage a world-class supply base, develop and manage supplier relationships, integrate suppliers into the new product/process develop process, integrate supplier into the order fulfilment process, supplier development and quality management and lastly manage costs strategically across the supply-chain. There are two processes in this framework that are of significance to this thesis, namely the third, establish and leverage a world class supply base management, and the eighth, manage costs strategically across the supply chain. Supply base management covers how many suppliers should source each category, as well as the conditions and requirements that are necessary for a supplier to be selected. This will be covered more in detail in section 3.3.3.

Moreover, managing costs strategically, also called strategic cost management by van Weele, will be discussed more in section 3.3.4. It involves identifying all costs, cost drivers and strategies aimed at reducing or eliminating costs throughout the supply chain. The work is meant to be a joint project by the supplier and buyer to realize cost savings which will result in a win-win situation for both parties, otherwise a lack of initiative and motivation will occur (Bäckstrand, 2019). The cost management work is the final process of the framework because these types of joint venture projects of cost saving can only be done when the buyer has developed a good relationship with the supplier and integrated them into the development process. To conclude, van Weele is positive to the framework based on previous experience with it, however not all products and suppliers will go through this process. The product and supplier in question needs to be of sufficient strategic importance in order to justify the time- and cost investments necessary to implement these processes into the firm's overall operations (van Weele, 2014).

3.6.3 Supplier selection

Remembering van Weele's (2022) purchasing process, the second stage in the model will be one of the main focuses for this thesis, namely supplier selection. According to van Weele, the supplier selection process can be divided into four steps: determining method of subcontracting, preliminary qualification of suppliers and drawing up the "bidders' list", preparation of the request for quotation and analysis of the bids received and selection of the supplier. It is important to note that after the method of subcontracting is determined, the buyer must specify requirements that the suppliers must live up to for the bidders' long list. These requirements can include lead time, quality, delivery reliability, price and so forth. This process leads into the third step in which the most promising suppliers from the long list are sorted out into a short bidders' list. Here is where each request for quotation (RFQ) is reviewed to finally lead the way to choosing the desired supplier. One of many methods to choose the final supplier can be with the help of cost management tools such as the should-cost model which will be explained in section 3.3.5 (van Weele, 2022).

These steps are, as previously mentioned, more tactical and operational in nature. If combined with the processes introduced in the purchasing excellence framework in section 3.3.2 the supplier selection can evolve to more strategic in nature if that is what is necessary for the product and supplier in question. Additional actions needed could involve benchmarking suppliers against how well they perform and their ability to co-operate with the buyer. After the supplier is chosen, the buyer can start developing and managing the supplier-buyer relationship to further integrate them into the long-term strategic objectives and goals the firm has set up.

3.6.4 Strategic cost management

As previously stated, the eighth step of the purchasing excellence framework involves how to implement cost management strategically across the supply chain. Van Weele (2022) also labels this as strategic cost management (SCM). Strategic cost management is a process and a way of acting that connects financial management, cost management and strategic management. It implements a holistic approach which involves optimizing cost and financial resource preparation which assists in achieving the company's desired strategic market position (Rounaghi, 2021). It requires a deep understanding of the underlying cost drivers within the business and its supply chain, focusing on both direct and indirect costs. SCM emphasizes creating value for customers and stakeholders by optimizing costs without compromising on quality or service. It encourages cross-functional collaboration, integrating efforts across departments to identify and implement cost-saving measures effectively. By managing costs strategically, companies can enhance their competitive advantage and ensure sustainable growth (Ellram, 2002).

Implementing SCM in an organization's day to day activities is important for several reasons. During Ellram's research, five large organizations were investigated regarding their use and perceived advantages of integrating SCM (Ellram, 2002). During research, it was found that organizations identified cost management as extremely important and growing in importance for the future. The reasons for this include declining sales, margin and prices, global competition, customers pressuring for lower prices, new markets, increasing regulations and changing demographics (Ellram, 2002; Rounaghi, 2021). Previously, organizations have focused on short-term cost reductions and therefore no sustainable change (Rounaghi, 2021). Now however, with the combination of these trends increases the need for organizations to find sustainable changes to prepare for what lies ahead.

The implementation of SCM is split into three stages which include value chain analysis, strategic situation analysis, and analysis of structural and administrative cost drivers. Firstly, the value chain analysis helps companies understand their competitive advantage in the market they are active in. It analyzes the organization's products from design to production and finally post-sales service. Through the value chain analysis, companies can identify the strengths and weaknesses which will build understanding in where costs can eventually be cut. Secondly, the strategic situation analysis examines the company's potential and current competitive advantage through activities and cost drivers that have been identified in the previous stage. Potential cost savings are determined depending on the company's overall strategy, whether it is cost leadership or competitive differentiation. Lastly, structural and administrative analysis is used to analyze which costs that indirectly affect the company's production can be cut. Cost drivers that are most often included are how the company works with scale, technology, the complexity in the products, administrative cost drivers, work commitment, design of production process and relationships with suppliers (Rounaghi, 2021).

There are several different types of cost models that can be derived from strategic cost management. These can be split into six categories: Total cost of ownership (TCO), Activity-based costing, Cost-ratio, Landed cost, Life-cycle costing and Cost structure analysis. The final model category includes several models such as should-cost analysis, target costing, value analysis and so forth. In thesis, the should-cost analysis is of specific importance and will be explained in detail in the section below (Ellram, 2002).

3.6.5 Should-cost analysis

There are several useful tools that organizations use to support the work within strategic cost management. One of the most used is the should-cost analysis. Should-cost analysis is cost management methodology in which a company identifies and estimates what a product, service, or piece of equipment should cost from a specific supplier. It can be used for all types of purchases. It is specifically used to determine whether a bid price from an RFQ or negotiation is reasonable as well as understanding where improvements can be found. In Ellram's research, it was found that should-cost analysis was most often used to facilitate improvements both within the organization and with suppliers, to increase the company's overall understanding of costs and where they come from, to improve relationships with suppliers and more. It is therefore a versatile tool that has become increasingly used by organizations over the last year (Ellram, 2002).

When to use should-cost analysis

The should-cost analysis is a time-consuming process; therefore, it is important to choose the correct situations in which to utilize it. As previously stated, the model is most commonly used during purchasing processes, but it might not be pertinent to implement it for every purchase. To solve this, the Kraljic matrix can be used to categorize which type of product are of specific importance and can therefore benefit from cost management (van Weele, 2022).

The Kraljic matrix splits purchased products into four categories depending on their strategic importance to the business and the risk of supplying it. It can be viewed in figure 3.5 below. The categories are: Strategic products, Bottleneck products, Routine products, and Leverage products. Strategic products are often high-tech, high-volume products which are usually specified according to the customer's specifications. Bottleneck products represent relatively low impact on the financial result for the business. However, these types of products are difficult to supply, sometimes only from one supplier. This results in the supplier having a dominant position compared to the purchaser which could affect prices, delivery times and services negatively. Routine products are simple items that are purchased often. They usually have a small value per item and therefore there are often several suppliers. Lastly, leverage products can most often be supplied from several different suppliers of similar standard quality. They represent a large part of the financial result for the company and are usually bought in large quantities (van Weele, 2022).

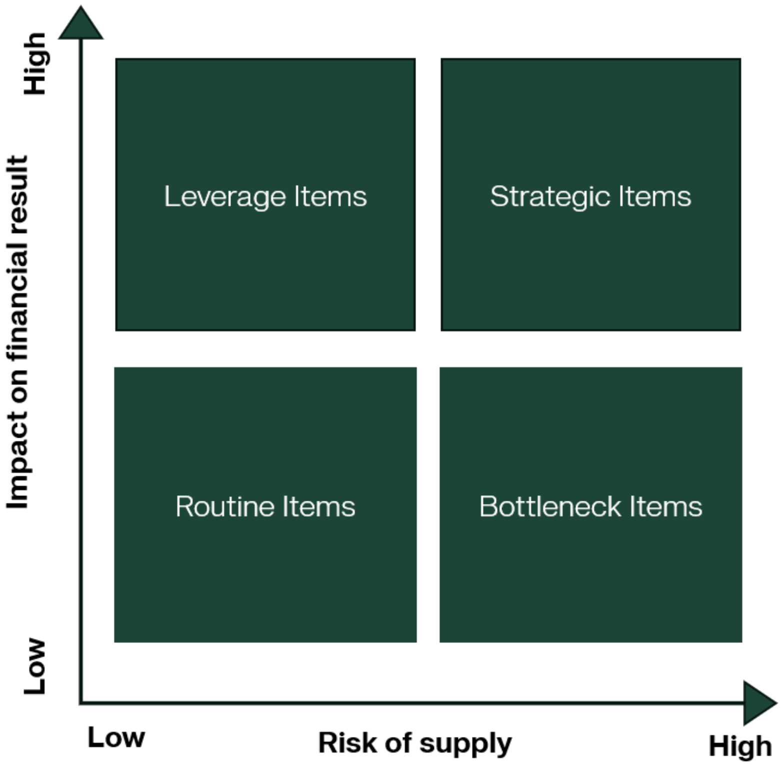

Figure 3.5: The Kraljic Matrix (van Weele, 2014)

Should-cost analysis is a tool that can help maintain long-term supplier relationships and control and cut procurement costs which is why it can be relevant to use when purchasing leverage and strategic products. These types of products have a large impact on the business' overall financial result, therefore cutting costs here will make a relatively large impact. Furthermore, ensuring that good supplier relationships are enforced, organizations can secure strategic products at a good price and sufficient reliability (Ellram, 2002).

Should-cost analysis process

The process of creating a should-cost model can vary depending on the industry, complexity of the product or service, and available data. QuestGlobal (2013) and Mealer and Park (2013) have introduced two separate processes for the should-cost analysis. QuestGlobal includes five steps in the should-cost analysis process: Input Study, Process Prerequisite, Cost Modeling, Outputs and Report Out. Mealer and Park includes, instead, seven steps: Identify The Sub Parts, Identify Raw Material (RM) And Manufacturing Process, Allocate North American Industrial Classification System (NAICS) Codes, Estimate Financial Ratios, Calculate RM Costs, Estimate Sub Part Should-Cost, Calculate The Total Should-Cost. Each of the processes is illustrated in appendix A in figure 8.1 and 8.2. For this thesis, we have chosen to compare each model and introduce a new process that takes inspiration from both. The process is illustrated in figure 3.6 below and will be described in detail.

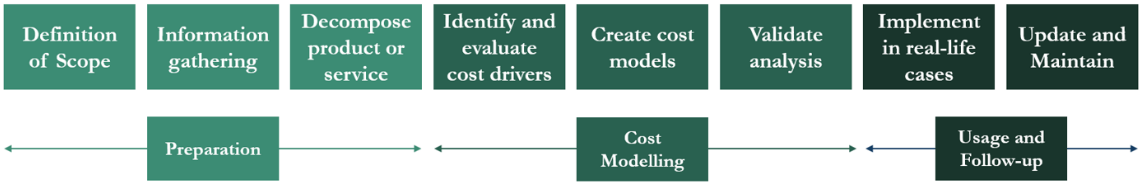

Figure 3.6: Should-cost analysis process (own illustration). Inspiration from QuestGlobal (2013) and Mealer and Park (2013)

As illustrated in figure 3.6, the stages of the process have been grouped into three parts, preparation, cost modelling, and usage and follow-up. The first three stages regarding preparation start with stage one which is about defining the scope of the analysis. This includes clearly understanding what product or service the analysis is to be conducted on, which part of the value chain is to be included, and what parts of the process are to be excluded. In stage two it is vital to gather detailed information regarding the product that is to be purchased. These might include material costs, labor costs, overhead costs, logistics, profit margins and so forth. In other words, any direct or indirect costs that are associated with the production of the product that are within the scope of the analysis. In the third and final stage of the preparation part, the product or service is decomposed into individual components or process. This breakdown can be based on physical components, manufacturing processes, or service steps, which allows for a detailed analysis of each part.

The second part of the process regards cost modelling and includes stages four to six. In stage four the cost drivers are identified and evaluated. These are the key factors that affect the cost of the product the most. These might include materials, labor, volume and so forth. These cost drivers should also be benchmarked compared to costs of similar products or services on the market to ensure that each cost driver is correctly identified and reasonable. These can be found through competitive bidding, industry reports, and supplier RFQs. In the fifth stage, cost models are created for each component or process in the production. All the relevant models are then aggregated to arrive at a total should-cost estimate of the product or service. The analysis is then validated in the sixth step to ensure that key cost drivers, cost models and aggregated sums are correctly calculated before heading into real-life uses.

The third and final part of the process oversees the use and follow-up of the analysis. Stage seven simply regards using the analysis in negotiations with suppliers or in in-house projects to reduce production costs. Lastly, in stage eight is about how to follow the analysis and model to ensure that it is up to date ahead of new negotiations or other use-cases. When new data is available, it should be correctly implemented into the models

3.7 Literature framework

The literature review highlights three major theoretical fields, the purchasing strategy, the process of making aluminum along with the environmental implications of it and the purchasing process. The insights provided by delving into each of these areas will enable the research question to be answered, once the analysis is complete. Together these fields create our literature framework with vital key words which can be viewed in figure 3.7 below.

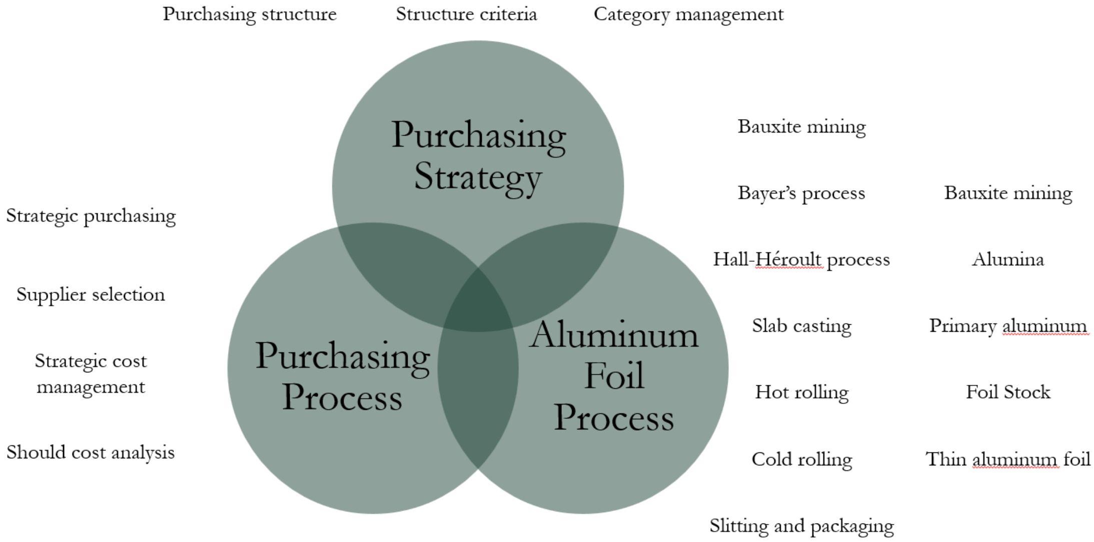

Figure 3.7: The literature framework with key words (own illustration)

Firstly, the theory underlying purchasing strategies sheds light on the crucial implications of adopting a should-costing tool in Northvolt's procurement processes. Given Northvolt's implementation of a category management system in its sourcing, understanding this aspect is particularly critical. Exploring the nature of direct materials and the strategies employed in their procurement will be instrumental in comprehending the impact of the analysis performed on aluminum foil, a key direct material.

Secondly, exploring the aluminum foil production process offers crucial insights into North America's aluminum foil capacity, where each stage adds distinct value and complexity. Given that the research objectives encompass various aspects and stages of production, it is essential to comprehensively chart the entire process. Through understanding the production process, it will assist in identifying relevant costs that need to be included in the should-cost analysis. Understanding the environmental impact of aluminum foil production in North America is vital for evaluating the capacity for low-carbon aluminum foil. This includes identifying the stages where GHG emissions are most significant and examining ongoing developments in the sector, which are key to assessing the future of aluminum foil production.

Lastly, the literature review rounds off by presenting the purchasing process by van Weele (2022). This theory is important to present because it opens the door to strategic purchasing, supplier selection, strategic cost management and, lastly, should-cost analysis. One of the main objectives of the thesis is to analyze how a should-cost analysis can benefit Northvolt's supplier selection, therefore it is vital that the analysis and the model are clearly presented. Moreover, the model cannot be presented without giving a background of where and why it was created, which is why the previous concepts are also clearly presented.

These three themes together create the literature framework, seen in figure 3.7, that will support the work in the rest of the thesis. The framework is illustrated via a Venn diagram because where the three themes overlap is where we can find the answer to the research question. The problem revolves around category management and direct category purchasing of aluminum foil in North

America as well as implementing strategic cost management and, specifically, a should-cost analysis on said purchase. By working closely with this framework, we can ensure that research and data analysis is done effectively and efficiently so that a trustworthy answer to the research question is found.

4 Empirics

In this chapter all quantitative and qualitative data that is required to answer the research objectives and question is gathered and presented. The chapter is divided into four parts in which the first section presents the quantitative data necessary to conduct the capacity analysis. The second section presents the quantitative data necessary to create the should-cost model and analysis. Finally, the last two parts presents the qualitative data which will explain how the capacity analysis and should-cost model can be applicable to and useful for the supplier selection and contracting process. The source of the data, as described in section 2.6, comes from company annual and sustainability reports, company website, news articles, market analyses, archived Northvolt documents and more. The data that has been collected will be analyzed and evaluated in chapter 5.

4.4 Capacity analysis

The first deliverable is to conduct a capacity analysis of the existing and future capacity of aluminum foil and its production stages as well as the environmental impact during each stage. There is no specific structure that needs to be followed when conducting such an analysis. The structure was decided by the authors together with the supervisor at Northvolt and will be presented in 4.1.1. The capacity analysis will be visualized through various mediums, including tables and own created figures.

4.4.1 Analysis structure

With the help of the information gathered in the literature review regarding the production process of aluminum foil, a structure of the analysis could be formed. According to the research objective, it was important to capture the current and future capacity and environmental impact for all stages of production. Therefore, the analysis was split into five outputs: bauxite, alumina, primary aluminum, foil stock, and lastly aluminum foil. Initially, the stages of production were used instead of production stage output which resulted in complications due to some of the production stages could also be used for other product outputs which are not relevant for the capacity analysis. It can be noted that the analysis does not include the process of slitting the aluminum foil to the customers desired width. This is because any serious manufacturer of aluminum foil will ensure that the capacity of the foil rolling will be roughly the same as the capacity for slitting foil. This eliminates an unnecessary bottleneck for the company (Aluminum foil expert, 2024).

For each output several data points were assigned to be found and inserted. Firstly, several companies have been listed which were identified to be the largest and most influential players for that specific output in North America. Secondly, each company's current capacity was recorded. Thirdly, each company's planned future capacity (if any) was recorded, as well as when the start of production (SOP) for the increased or decreased capacity. Fourthly, the company's GHG intensity for both scope 1+2 and scope 1+2+3 was recorded. In other words, each company's GHG emissions per ton output. Fifthly, the climate goals and ambitions were recorded. Sixthly, each company's revenue and main customer segment was inserted. Lastly, the process' output total capacity in North America is recorded. The capacity analysis structure can be viewed in the summarized in table 4.1 below.

Table 4.1: Capacity analysis structure

Process Output	Company	Current Capacity	Future Capacity	SOP	CO2 scope 1+2	CO2 scope 1+2+3	Climate goals	Revenue	Main customer segment	Total capacity
Bauxite										
Alumina										
Primary aluminum										
Foil stock										
X µ thin aluminum foil										

In total nine different data points were gathered for each company in each stage of output. The most vital data points were the current and future capacity, current environment impact and future goals and ambitions connected to emissions. Value is added to the analysis and to Northvolt by adding several important players to each output. It is also important to insert each company's revenue and main customer segment to present further context to Northvolt. To provide context to the analysis, it was decided to include the projected demand for battery cathode foil. This involved collecting data on the production capabilities planned for the future, as announced by key industry leaders in battery manufacturing and news articles. When assessing the capacity of output of a battery producing facility or company, the unit of measurement is often in giga-watt hours (GWh). According to Max Hedsand, Category Manager at Northvolt, one GWh equivalent of battery production corresponds to a need of approximately 140 tons of battery cathode foil (Hedsand, 2024).

The overall structure and chosen data points were done through discussions with Max Hedsand and through interviews with an aluminum foil expert employed by Northvolt.

4.4.2 Company selection

Company selection was conducted as described in section 2.6.1 together with the criteria. The companies that were selected to be included in the capacity analysis can be viewed in figure 4.1 below along with which parts of the aluminum foil production stages they are a part of. Moreover, a more detailed description of each company can be found in appendix B.

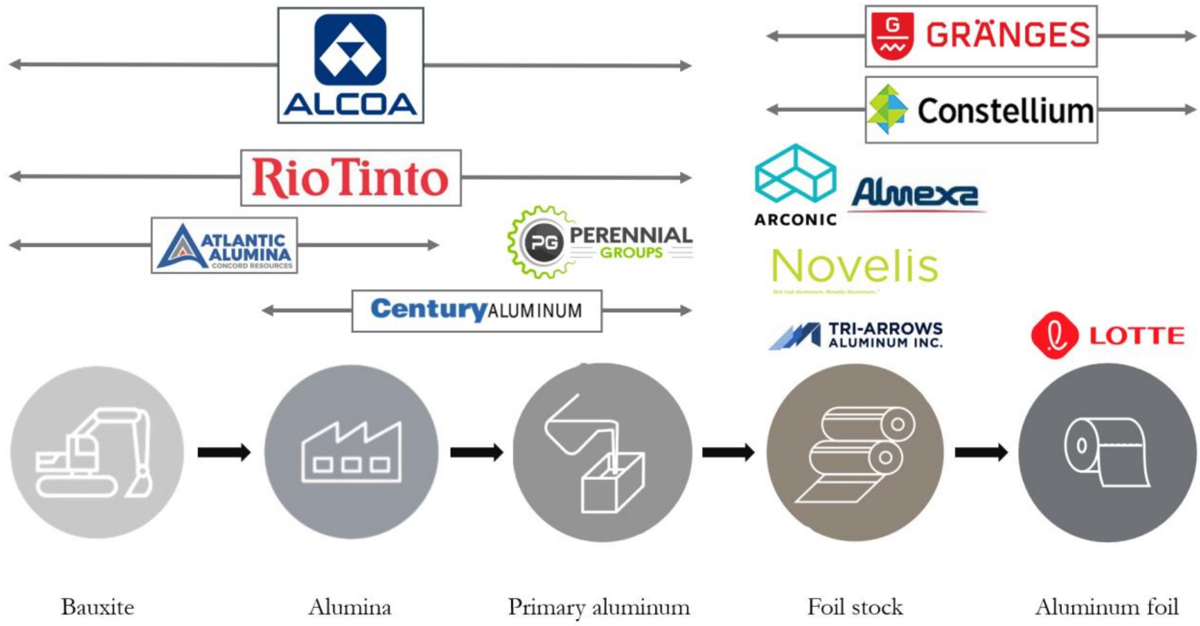

Figure 4.1: Selected companies and operations in the value chain

Regarding the gathering of data related to the demand of battery cathode foil, all factories with an output of one or more GWh worth of battery production per year were included.

4.4.3 Data gathering

As previously mentioned in section 2.6.1, the data points that were gathered were found through reading companies' websites, annual reports, sustainability reports, news articles, and market analyses. Most of the data points in question were found through these different sources, however some calculations and assumptions had to be made to estimate a company's capacity. For example, dividing the total GHG emission with the GHG emission intensity to get the total production volume. This means that some of the data presented is more reliable than others. This is visualized through color coding each cell with a green, yellow or red tag. With green being the most reliable and red the least. However, it is important to note that untrustworthy data was not included and should not be confused with red-marked data which only means that the data is less reliable than green-marked data. The green-marked data represents values which are directly gathered from each respective company site and are considered reliable. The yellow-marked data represents values which originate from each respective company site but required slight tweaking or assumptions to be applicable. The red-marked data represents values which required assumptions and/or calculations to be applicable or values which are considered unrealistic.

The data values of companies' production of electric vehicle batteries are either based off public announcements or speculations from news articles. Even though the validity of speculations is low, it gives an indication of the maximum demand of cathode foil in North America.

4.4.4 Capacity analysis result

In the following section, the result of the gathered data is presented. In table 4.2, the resulting capacity of the chosen companies and data points is summarized, along with a visualization of the corresponding locations shown in figure 4.2.

Due to the geographical conditions required by bauxite ore, bauxite is non-existent in North America. Therefore, it must be imported for companies such as Rio Tinto, Alcoa and Century Aluminum to refine into alumina. Because of the delimitations of the thesis, which is to analyze production and capacity performed in North America, the capacity of mining bauxite has been removed from the structure of the analysis.

Following the creation of the analysis structure, choice of which data points to include, which suppliers to include in the analysis and the demand of cathode foil in North America, the following data and results were gathered.

Supplier current capacity and GHG emissions

In table 4.2 below all the 12 suppliers chosen for the analysis are presented together with their respective operations, current capacity and GHG emissions. Their future capacity and environmental goals are presented further in this section. Each company is color coded to represent their location in the map in figure 4.2 below the table.

Table 4.2: Capacity Analysis

Company	Location	Operations	Capacity (kt/year)	Scope 1+2+3 (kg CO_2 /kg output)	Source
Atalco	Louisiana, USA	Alumina	1200 [1]	0,74 (scope 1+2)** [1]	[1] (Atalco, n.d.)
Rio Tinto	Quebec and British Columbia, Canada	Alumina | Primary Aluminum	1500 | 2663 [2]	7,4 [3]	[2] (Rio Tinto, 2024) [3] (Rio Tinto, 2023)
Alcoa	Quebec, Canada New York and Indiana, USA	Alumina | Primary Aluminum	2718 | 1359 [4]	5,3 (scope 1+2)** [5]	[4] (Alcoa, 2023) [5] (Alcoa, n.d.)
Century Aluminum	Kentucky, USA South Carolina, USA	Alumina | Primary Aluminum	1400 [6] | 709 [7]	6 (scope 1+2)** [8]	[6] (Century Aluminum, n.d.) [7] (Century Aluminum, n.d.) [8] (Century Aluminum, 2023)

	The PerenniAl Group	N/A	Primary Aluminum	265 [9]	N/A	[9] (The PerenniAl Group, n.d.)
	Constellium	Alabama, USA West Virginia, USA	Foil Stock	621 [10]	5,1 [11]	[10] (Constellium, 2023) [11] (Constellium, 2023)
	Novelis		Foil Stock	1467* [12]	6,9 [13]	[12] (Novelis, 2022) [13] (Novelis, 2023)
	Arconic	Tennessee, USA	Foil Stock	815 [14]	9,3 [15]	[14] (Arconic, 2022) [15] (Arconic, 2022)
	Tri-Arrow Aluminum	Kentucky, USA	Foil Stock	450 [16]	0,98 (scope 1+2)** [17]	[16] (UAJC, 2023) [17] (UACJ, 2023)
	Almexa	Cuautitlán Izcalli, Mexico Veracruz, Mexico	Foil Stock	36 [18]	2,9 [19]	[18] (Vasconia Group, 2022) [19] (Vasconia Group, 2022)
	Gränges	Arkansas, USA	Foil Stock | Thin Foil	200 | 6 [20]	6,2	[20] (Gränges, 2023)
	Lotte	Kentucky, USA	Thin Foil	36 [21]	SOP 2025***	[21] (Team Kentucky, 2022)

* North American sales volume
** Scope 3 figures not reported
*** Start of production (SOP)

As previously stated, each supplier has been color coded to represent them in the map in figure 4.2 below. Some suppliers operate in several parts of the value chain and have several production facilities which is why, for example, Rio Tinto has two different types of forms and two locations. Circles represent manufacturers of alumina, triangles represent primary aluminum manufacturers, squares represent foil stock producers and stars represent thin foil producers. The size of the area of the markers represents their respective current capacity. The location of Northvolt's new gigafactory is also placed in Montreal, Canada.

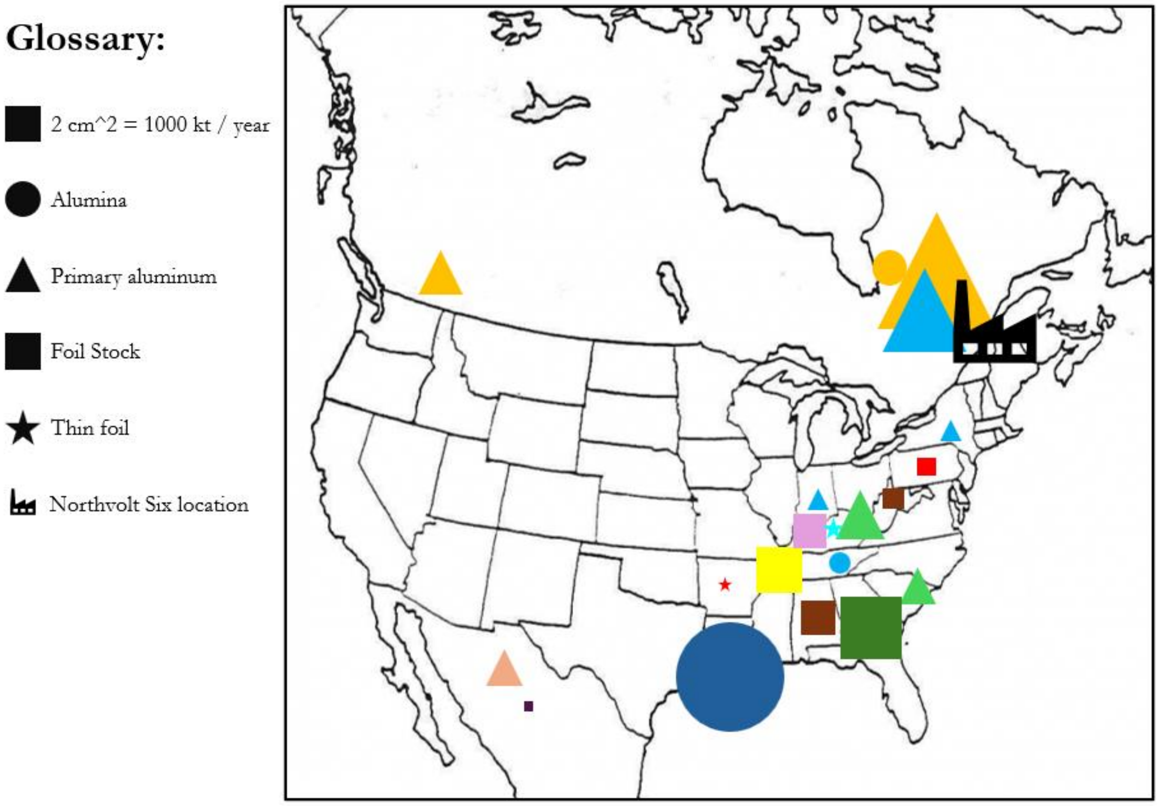

Figure 4.2: Map of suppliers with size representing capacity and form representing operation (own illustration)

Supplier future capacity and future environmental goals

Following the presentation of the suppliers' current capacity and GHG emissions, table 4.3 below presents what plans each supplier has regarding future capacity of the relevant output as well as strategic plans to reduce their environmental impact. Only a few of the suppliers have publicly released their increased capacity plans, while almost all have very similar plans to reduce their GHG emissions.

Table 4.3: Future capacity and environmental goals for each supplier

Company	Operations	Future capacity goals	Environmental goals	Source
Atalco	Alumina	-	-	
Rio Tinto	Alumina | Primary Aluminum	- | +160 kt [22]	New $1,1B investment decrease smelting emission to 1,6 t CO2/t Aluminum [22]	[22] (Rio Tinto, 2023)
Alcoa	Alumina | Primary Aluminum	-	Reduce GHG emission by 30% by 2030 (scope 1+2) compared to 2015. Net-zero emission 2050 [5]	[5] (Alcoa, n.d.)

Century Aluminum	Alumina | Primary Aluminum	-	Reduce GHG emission by 30% by 2023 and net-zero emission by 2050 [8]	[8] (Century Aluminum, n.d.)
The PerenniAl Group	Primary Aluminum	-	-	[23] (The PerenniAl Group, n.d.)
Constellium	Foil Stock	Focus on recycling, outside of thesis scope [11]	Reduce scope 1, 2 and 3 GHG intensity by 30% 2030 vs 2021. Reduce scope 1 and 2 ghg intensity by 30% in 2030 compared to 2021 [11]	[11] (Constellium, 2023)
Novelis	Foil Stock	Focus on recycling, outside of thesis scope [13]	30% reduction in GHG emission by 2030 compared 2016 [13]	[13] (Novelis, 2023)
Arconic	Foil Stock		Reduce scope 1, 2 and 3 ghg intensity by 30% 2030 compared to 2021, reduce energy intensity by 10% [15]	[15] (Arconic, 2022)
Tri-Arrow Aluminum	Foil Stock	Increase productivity by 13% [17]	Reduce GHG emission by 30% by 2030. Carbon neutral by 2050 [17]	[17] (UACJ, 2023)
Almexa	Foil Stock	Quadruple current production capacity [18]	-7.8% scope 1, -8.1% scope 2, -12.2% scope 3, all per year. Forecasted GHG intensity is 1,3 kg CO_2/kg Al by 2027 [19]	[18] (Vasconia Group, 2022) [19] (Vasconia Group, 2022)
Gränges	Foil Stock | Thin Foil	New casting centers | Ongoing investments to increase foil capacity [20]	Net-zero 2040. -60% GHG emissions by 2030 compared to 2017 [20]	[20] (Gränges, 2023)
Lotte	Thin Foil	-	-	

Total capacity flowchart

Furthermore, the total capacity for each production stage output can be visualized in figure 4.3 to clearly show how the total capacity differs for each production stage. It also clearly illustrates where bottlenecks in aluminum foil production can be found in North America.

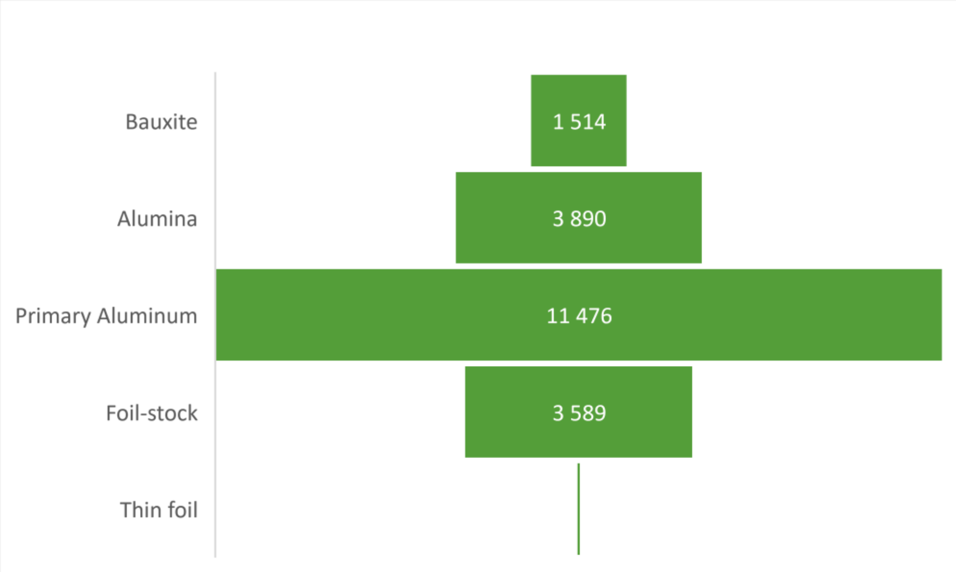

Figure 4.3: Flow chart of thin foil production, in metric kilotons

Demand of aluminum cathode foil

In figure 4.4 below is the forecasted demand and capacity of cathode foil and thin foil respectively. The forecasted demand data is sourced from the respective companies' websites and news articles, and which means that both public announcements and speculation have been included to present a maximum forecasted demand. The included companies and announced facilities with their respective output in GWh is presented in appendix B.

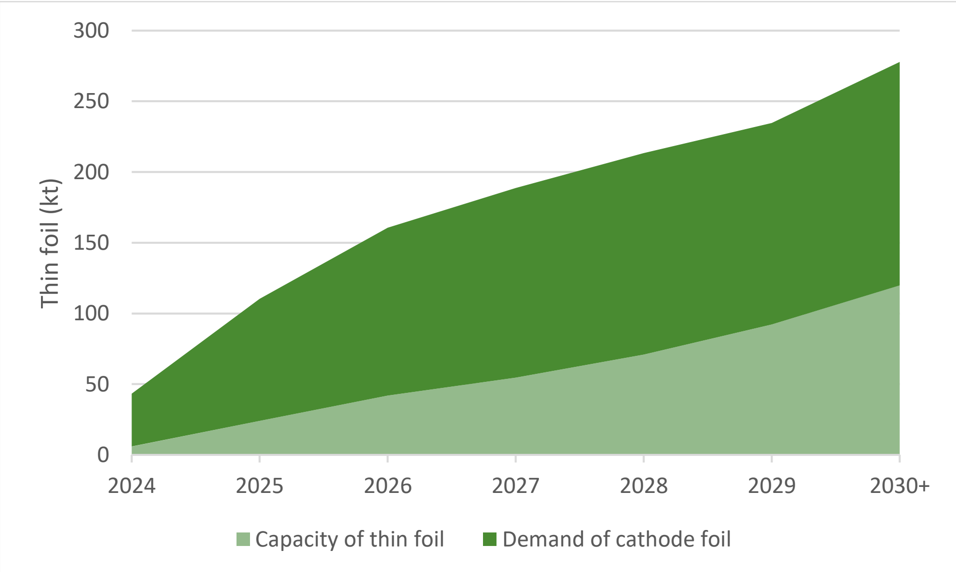

Figure 4.4: Current and forecasted demand and capacity of cathode foil and thin foil respectively

4.5 Should-cost analysis

As previously mentioned, the second deliverable is the should-cost analysis which has the purpose of estimating the manufacturing costs for tier one supplier, in other words companies that can supply Northvolt with the 5-20 μm thick aluminum foil. In order to understand how to build the should-cost model, the process introduced in section 3.3.5 will be followed. A graphical depiction of the process can be viewed again in figure 4.5.

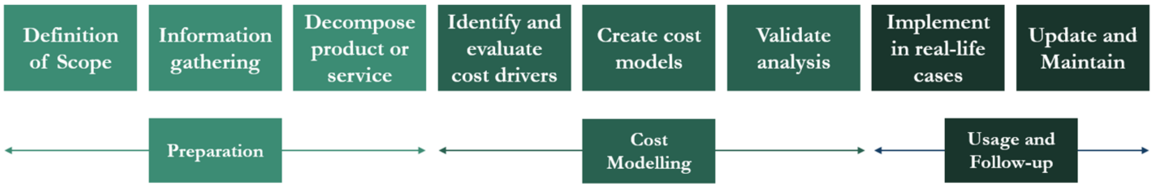

Figure 4.5: The should-cost analysis process (own illustration)

Most of the preparation stage has already been conducted during the literature review. In other words, the definition of scope has been defined as tier one manufacturers 5-20 µm thin aluminum foil in North America. Furthermore, the product has been decomposed during the literature review into its fundamental production processes and components. The empirical study has, regarding the should-cost analysis, the purpose of gathering information in the preparation phase and identifying and evaluating cost drivers for aluminum foil production.

4.5.1 Model structure

Before knowing what data to gather, the model's structure must be decided. This model is a known practice but has not been applied for this purpose. This implies that some of the model's parameters are going to be standard while others are purposefully chosen for this situation. It is important to note the tier one production for aluminum foil includes production stages that, according to the literature review, all companies have. These production stages include cold rolling pass, slitting and packaging. Passing the raw material (foil stock) through the cold rolling mill is the operation that takes the most time and the foil stock must undergo several passes depending on the thickness of the raw material that is procured. This makes it difficult to assess the capacity of a facility. The output will drastically impact the should-cost price per unit of weight, which is why it is crucial to estimate it with high precision. By starting from the theoretically maximized capacity in a standardized Achenbach set-up and removing capacity due to the factors: downtime, scrap, and width suboptimization, the result should be accurate to a satisfying level. The standardized Achenbach set-up is sourced from an internal confidential document.

In addition to the production stages the cost drivers must be decided. These can be found in table 4.4. The cost drivers that were chosen to be included: raw material, equipment, labor, energy usage, depreciation of equipment and buildings, miscellaneous, overhead, packaging, transportation, warehousing, financial costs, and profit. These cost drivers were chosen with aid from both the literature review and during the first and second workshop with Northvolt. Some cost drivers are broken down to core components to calculate the should-cost for the drivers that are more complex. The components and units that are included in each cost driver are presented in the second column. Furthermore, because the costs of electricity, operators, and so forth differ between each country and state relevant in North America, according to the capacity analysis, these cost drivers' values alter depending on which country and state that wants to be analyzed. The overall structure of the should-cost model can be viewed in table 4.4 below. However, while the model allows for manual input for all parameters, there is an option to apply industry standards, averages, or estimations if the user lacks specific information. These are gathered in a separate Excel sheet to the model.

4.5.2 Information gathering

After the overall structure had been created, a plan was created regarding how information gathering would be conducted. Based on the literature framework, the most obvious cost factors could be assessed and estimated. However, to manage the not so obvious sources of cost, different approaches were necessary. By iteratively building the model and validating it with company experts, all fundamental factors for cost were implemented and accounted for. The mentioned experts gave advice and inspiration for which factors to include, how to assess them and where to find information regarding this. The sources of information include confidential Northvolt documents, public company reports, expert knowledge, public statistics and estimations.

4.5.3 Should-cost model presentation

The finished model covers 12 different aspects which all affect the cost of producing aluminum foil. The two final aspects, LME premium and cost are not relevant for the production of aluminum foil but affect what the should-cost is as they are added onto the production cost. In table 4.4 below, these are described together with the corresponding cost drivers. In addition to table 4.4, table 8.3 in appendix D presents 60 variable parameters that are used to calculate the different cost drivers. The parameters either have standard values for this industry or average values for the specified country and state. The parameters can also be altered to a specific supplier's costs and situation to model a more precise should-cost. If, however, no supplier specific data has been inputted, the average or standard values will be used instead.

Table 4.4: Should-cost model aspects and cost driver with respective descriptions

Aspect	Cost driver and unit	Description
Capacity	Width machine (mm)	The maximum foil stock input width
	Theoretical capacity (t/year)	Achenbach's recommended theoretical yearly output for a set-up with 3 rolling mills and 4 slitters
	Capacity loss due to width (t/year)	If the desired foil width is less than the maximum input, capacity will be lost
	Capacity loss due to scrap (t/year)	Capacity lost due to poor production quality
	Capacity loss due to off time (t/year)	Capacity lost due to off days
	Real capacity (t/year)	Capacity values for each production process: rolling, slitting and packaging
	Output (t/year)	The output of foil in tons/year. Is going to be the minima of the row above, in other words the bottleneck process
Raw material	Raw material foil stock ($/kg)	Cost of foil stock
Equipment	Machines in use (#)	How many machines are in use for each process if different from 3+4 set-up described above: rolling and slitting
Operators	Operators (#/shift)	How many operators are needed for each process: rolling, slitting, packaging and others
	Shifts (#/day)	Facilities like this are assumed to operate around the clock, so 3 shifts per day if shifts are 8 hours long
	Hours (#/shift)	Operators are assumed to work 8 hours per shift
	Hours total (h/day)	Total payable hours per day for all operators

	Salary ($/h)	Average blue-collar worker in the selected country and state/province
	Cost of Operators ($/year)	Total cost for operators per year
	$/kg	Cost per kilo output
Energy	Energy source	Shows which energy source has majority in specified country and state/province
	Cost ($)	Total cost for electricity which includes $/kWh, kWh/kg produced foil and output per year
	$/kg	Cost for electricity per kg
Depreciation	Value of equipment (incl. installation) ($)	The total value of all equipment for production which includes rolling mills, slitters, air purifiers, scrap handling etc. also including installation costs
	Cost of depreciation equipment ($/kg)	Cost per kg for the depreciation of equipment. Number of years depreciated can be 5-30 years
	Value of buildings ($)	Total value for factory building
	Cost of depreciation buildings ($/kg)	Cost per kg for the depreciation of buildings. Number of years depreciated can be 10-40 years
	Value of land ($)	Total value for land
	Cost of depreciation Land ($/kg)	Cost per kg for the depreciation of land. Number of years depreciated can be 10-40 years
Misc.	Oil Usage (l)	Total yearly rolling mill oil usage
	Cost per liter ($/l)	Cost for the oil per liter
	$/kg	Cost of rolling oil per kg
Warehousing	Inventory interest value cost ($/safety stock)	Bound up capital in finished goods warehouse

	Inventory interest value cost ($/kg)	Cost per kg produced aluminum foil due to interest value loss in bound up capital
Transportation	Packaging box price ($/kg)	Cost of purchasing a box for packaging. These boxes can be reused 5 times
	Packaging box return ($/kg)	Cost for return packaging box
	Core Amount (#/year)	The number of cores (a roll which the aluminum foil is rolled onto) used per year
	Core Cost ($/kg)	The cost of the cores per kg
	Core Return ($/kg)	Cost of returned the core to supplier.
Finances	Total finance costs ($/year)	All finance costs related to interest on debt per year
	Finance cost ($/kg)	Interest costs per kg
Overhead	$/kg	SG&A or overhead costs which include administrative, sales etc. Is calculated with a % but presented as $/kg
Profit margin	$/kg	Profit per kg supplier takes. Is calculated with a % but presented as $/kg
Conversion cost	$/kg	The overall production cost per kg, also known as conversion cost
LME Premium	$/kg	The premium price for aluminum per kg
LME Cost	$/kg	The aluminum price per kg, based on the metal stock-exchange
Should-cost	$/kg	The should-cost for 1 kg aluminum foil

4.6 Northvolt procurement structure and strategy

This section presents the data gathered from the interviews conducted with Northvolt employees regarding procurement structure and strategy. The data is described in text and divided into how the questions were asked. If nothing else is stated, the information and data presented is from the specified interviews. Additionally, summaries of all the answers are presented in table 8.4 in appendix F.

4.6.1 Procurement structure and strategy

Procurement strategies involve organizational structures, sourcing strategies, and the role of category management at Northvolt. Regarding the purchasing structure at Northvolt, the interviewees were not aligned in their opinions. Some believed that Northvolt has adopted a centralized structure while others identified it to be hybrid. They were, however, aligned in that Northvolt has created policies and guidelines regarding their purchasing process that all purchasing units should follow.

Northvolt has been very clear that their goal is to establish a regional supply chain for each gigafactory and to incorporate several suppliers for each category. These choices in procurement strategy are based on two main explanations. Firstly, the environmental impact plays a pivotal role for Northvolt's overall business strategy, which is directly related to their procurement strategy. They believe that sourcing their products and services locally helps them to accomplish their environmental goals. Secondly, sourcing locally helps to minimize certain supply risks, of which there are several. Some examples of supply risks include: problems due to the product's size, corruption in offshore countries, production halt due to critical product missing, and long lead times. However, the category managers are aware of the main trade-off to this sourcing strategy is to pay a premium. This can be reflected throughout the entire business strategy, where they also consider their end-product to be priced as a premium.

Lastly, supply chain management is a large focus at Northvolt. The CEO and founder's career is characterized by this thought process after heavy focus in supply chain management at Tesla. To enable Northvolt to secure their demand efficiently and effectively, they have adopted a category management procurement strategy. The category managers interviewed believe that there is no other option to choose from and that it is common practice. It enables people from around the globe to join the company and quickly adapt to this well-known practice. Furthermore, because Northvolt procures a lot of different services and products, it becomes a lot easier to know who owns which category and how to contact them.

4.6.2 Supplier selection

Similar to the overall purchasing process at Northvolt, the supplier selection process is a highly standardized process for all purchasing units. This process involves several complex steps and criteria that all suppliers must go through.

Outside of the actual supplier selection process, the category managers must have one other important criterion in mind. Managers should opt to choose suppliers that are willing and able to build long-lasting relationships with Northvolt. There are several reasons for this. For some categories, Northvolt is involved in the process of designing and developing the product. Therefore, if the supplier relationship was broken, it would take a lot of time to re-start production connected to that product. Secondly, Northvolt believes that a long-lasting supplier relationship can improve several important aspects such as quality, lead time, production, costs and so forth. Lastly, Northvolt wants their suppliers to share the same business philosophy, where leading environmental ambitions and collaborative development has great focus. Not only reap the rewards when times are good, but also help Northvolt when business is tough.

4.6.3 Negotiations

Regarding negotiations at Northvolt, there is no companywide policy on how to conduct these. Each category manager should in their own way choose and prepare how to conduct their negotiations. Furthermore, it is the manager's responsibility to ensure that the internal goals, such as cost, quality, service, environmental impact and more, are achieved in these negotiations.

4.7 Benefits of capacity and should-cost analysis implementation

This segment delves into the opinions regarding the relevance, familiarity, contributions, and considerations of both the deliverables. Likewise, if nothing else is stated, the information presented below is completely based on the answers provided from the conducted interviews, found in appendix F.

4.7.1 Category managers' perceived value of the capacity analysis

During this section of the interview, the familiarity of the capacity analysis and other similar analytics were discussed, along with the relevance and contribution this offers to the processes of procurement. The information presented in this section can be found in appendix F, table 8.5.

Relevance and familiarity

The level of familiarity of a capacity analysis varies between the different category managers, this originates from the amount of relevance this type of analysis has to the respective categories. It was evident that the more complex the product or market, the less relevant an analysis of the capacity is. For example, in categories with few suppliers possessing the necessary capacity, mapping out procurement potential may provide limited value. Similarly, for complex or custom-made products tailored to customer specifications, it becomes challenging to identify suppliers capable of meeting these specific needs.

For commodities similar to foil, where the level of standardization is high, the capacity analysis is considered to be of high relevance. This is due to the amount of supply significantly exceeding the demand of Northvolt, which enables the strategic selection of suppliers most beneficial in terms of price, quality, service, and environmental philosophy.

Contributions and considerations

For commodities where the application of a capacity analysis is relevant, the category managers believe the contribution to the procurement is of high value. It provides a foundation for understanding the existing market situation and risks, which is beneficial for securing supply. It was deemed most relevant for scenarios where new markets were being analyzed, either by entering new geographical locations or supplying new products. In Northvolt's case, it is considered important that the suppliers share the same philosophy environmental ambitions, which the capacity analysis can assist in identifying.

Some of the interviewees raised concerns regarding the potential for a false perception of the future market situation. Where the possibility of overzealousness might lead to unsatisfied production investments, as the projected demand was overestimated. The relevance of including different data points was also brought up, where regulations and legal requirements were considered. This becomes especially impactful as the analysis is applied in new geographical locations, where the local regulations and legal requirements may significantly differ from the company's primary operating region.

4.7.2 Category managers' perceived value of the should-cost model

The purpose of the last section in interviews was to gather data regarding how the category managers view strategic cost management in their work and specifically their opinions on the use of a should-cost model. The information presented in this section can be found in appendix F, table 8.6.

Relevance and familiarity

The concept of strategic cost management is not widely recognized among the interviewed category managers. However, upon receiving a brief explanation, several managers identified aspects of their work that align with this approach. Despite this, there is consensus that strategic cost management has not been explicitly mandated by upper management. Instead, the responsibility for implementing strategies to reduce prices and costs to meet internal targets rests with individual categories or purchasing teams. As a result, the adoption of strategic cost management practices has not been uniformly enforced or promoted at the higher levels of the organization.

Regarding the should-cost model, the interviewed category managers were more familiar with this concept. Some of the managers have personally conducted their own should-cost models, while others have utilized the help of cost engineers. In both cases their experiences have been positive. It was, however, clear that the relevance of such a model is different depending on the product and category. Nevertheless, all interviewed managers agreed that implementing such a model and working with bringing down costs together with partnered suppliers is highly relevant for Northvolt.

Contribution

The effectiveness of the should-cost model varies across different purchasing units at Northvolt. Managers responsible for acquiring products that require minimal modifications and are less tailored to Northvolt's specific needs see significant benefits in utilizing a should-cost model. Conversely, managers dealing with highly customized products designed exclusively for Northvolt find less relevance in this model. Nevertheless, all managers emphasized the importance of dissecting and analyzing cost drivers for the products they purchase. This analysis is a key component of the should-cost model process.

Moreover, all managers agree that the should-cost model is highly valuable in the supplier selection and negotiation processes. It serves as a tool to collaborate with or challenge suppliers to reduce costs. Additionally, the model's accuracy improves when suppliers participate in auditing it. However, if suppliers are unwilling to cooperate, employing the should-cost model can come across as aggressive and may not achieve the desired cost reductions. Additionally, one manager noted that the model is also useful for evaluating suppliers, a task previously supported by Analytic Hierarchy Process (AHP) analysis.

4.8 Summary of empirics

This section aims to summarize the entire empirics chapter, with focus on the capacity analysis, should-cost analysis, and the process of gathering qualitative data through interviews.

4.8.1 Capacity analysis

Through the gathering of quantitative data an extensive capacity analysis has been created of aluminum foil in North America. The result was an analysis of 12 players in the value chain, from alumina refinement to the rolling of thin aluminum foil. All relevant data points were gathered to build an understanding of the situation of this industry in North America. This included: mapping where these companies' production is located, their maximum production capacity to date and future capacity expansion plans and carbon offset values to date and goals for the future. These values can assist in analyzing bottlenecks in production. Furthermore, the projected future demand for battery cathode foil was calculated and visualized against the current and future capacity to understand whether Northvolt can successfully secure local sourcing of cathode foil ahead of the opening of their new factory.

4.8.2 Should-cost analysis

By keeping the theory regarding aluminum foil manufacturing in mind, along with the process of creating should-costing models, the resulting model is successfully estimating the cost of producing cathode foil. The model has been validated through two workshops with different experts in the field. As mentioned, the process of making the model accurate is done by incorporating more and more relevant and realistic values. This means that accessing valuable data will be of significance to the model's potential for application in negotiations. As of now, the model is mainly basing its estimation on averages and standards in the industry, where most do not originate from real supplier data.

4.8.3 Interviews

In total six interviews were conducted with category managers from two different purchasing units at Northvolt. These interviews gave valuable insight into the contribution the two deliverables this thesis has created can have for Northvolt's supplier selection and negotiation processes. The interviews also gave insight into the purchasing organization at Northvolt, regarding procurement strategy, supplier selection and negotiation processes that will be further analyzed in chapter 5 against the theory built for this thesis.

5 Analysis

Based on the findings from previous chapters, this chapter will analyze, firstly, what the findings regarding the capacity analysis can show Northvolt. Secondly, other use cases that model can offer Northvolt excluding negotiations. Thirdly, how these deliverables are of use and value for Northvolt ahead of their gigafactory opening in Montreal, Canada. Lastly, a discussion is presented regarding the data quality in all deliverables. The analysis in this chapter is as stated based on the data from chapter 4 but will also be connected to the theory presented in the literature review in chapter 3.

5.4 Implications of the capacity analysis

This section aims to analyze the empirics regarding the capacity analysis of aluminum foil in North America presented in the previous chapter. The two main analysis points regard the carbon footprint situation of the aluminum foil value chain in North America and the dynamics between the supply and demand of aluminum battery cathode foil.

5.4.1 Environmental discrepancies and trends

The capacity analysis revealed significant variations in the carbon footprint ambitions among the analyzed companies. The GHG emissions associated with each kilogram of production ranged from as low as 2,9 kg of CO_2 equivalents to as high as 9,3 kg, encompassing scope 1, 2, and 3 emissions. This discrepancy underscores the influence of industry trends aimed at carbon footprint reduction, as highlighted in the literature review. The extent to which a company can produce low-carbon aluminum is linked to its adaptation to technological advancements, recycling practices, and energy source optimization. Such adaptations are crucial for explaining the observed differences in carbon footprints across the analyzed companies. Companies that have embraced modern smelting technologies, integrated recycled materials efficiently, and sourced energy from hydroelectric or other renewable sources tend to have a significantly lower carbon footprint. Figure 4.2 illustrates where the analyzed production factories are located in North America. Factories that are situated in Quebec, Canada have the advantage of utilizing hydroelectric power, whereas factories located along the east coast in USA are forced to purchase electricity from fossil fuel sources. Therefore, new players should consider this when deciding the location of their new factory.

Regarding the future environmental goals, many companies indicated similar ambitions, where the majority had the desire to lower the GHG intensity by 30% by the year 2030. A trend which could be indicated by the announced environmental goals is that companies mainly producing primary aluminum tend to focus on scope 1+2, while companies lower down in the value chain includes scope 3 emissions. Whether the overall sustainability goals succeed will therefore be heavily dictated by the level of success primary producers achieve in the transition to low-carbon production. If they succeed, the companies lower down in the value chain with scope 3 environmental goals will "succeed" as well. This is due to the majority of their scope 1+2+3 emissions originating from the most carbon intensive process step in the value chain, the production of primary aluminum.

5.4.2 Supply and demand dynamic

In figure 4.4, the projected supply and demand for thin foil and battery cathode foil is illustrated. Based on this figure it becomes evident that the future North American market will suffer from a shortage of locally produced cathode foil. This does not have to be the reality though since there are more factors and possibilities to consider. It is unknown how and where the analyzed companies on the demand side will source their cathode foil, meaning that they could have a secure supply already contracted. It is possible that they either have in-house production or source from cheaper manufacturing countries, such as China, which is a major aluminum producer. A large part of the companies has Asian origins, whereas this becomes even more probable. However, for new cathode foil customers in the market, it is beneficial if the competition between cathode foil suppliers intensifies, to enable better negotiation terms and securing supply.

Moreover, the flowchart in figure 4.3 reiterates the concern over cathode foil scarcity. Yet, it also underscores a notable opportunity: the potential for North America to pivot its production capabilities towards meeting this demand. Given the substantial volume of primary aluminum produced in the region, there exists a possibility for transitioning production focus towards foil, thereby addressing the projected shortfall. This suggests that, with strategic adjustments and investments, North America could feasibly counteract the anticipated market shortage by leveraging its existing aluminum production capacity. The shortage of foil could also explain why foreign players such as Lotte and Gränges have chosen to establish production in North America.

5.5 Benefits and considerations of should-costing

This section aims to analyze the should-cost model that has been created for Northvolt. Analysis points include how the model can be of use to Northvolt, excluding the main contribution that the interviewees identified. These use cases include comparing costs with previous quotes to identify improvements that can be made and conducting a weight analysis to identify which cost driver has the largest impact on the overall should-cost. Lastly, an analysis will be conducted as to how the model can be improved for further use.

5.5.1 Cost comparison

During construction of the model, individual cost models and values were compared to previous supplier quotes to find discrepancies and improvements. During this process, it was discovered that some costs given by the supplier were significantly different compared to those of the model. This was especially true for the cost per kWh of electricity. After validating that the model's value was true, it was assumed that the supplier had exaggerated the cost of electricity in the hope that Northvolt would not notice. Therefore, the model is a good reference and comparison when analyzing the costs presented by suppliers in quotes. Also, it is therefore important to be critical when inserting data provided by suppliers into the model.

5.5.2 Weight analysis

In addition to comparing quotes, the should-cost model also enables analysis on the cost impact of all the included parameters in the model, which is referred to as a weight analysis. This was done by setting all the parameters to the average or standard value, and then increasing them one at a time by 10 percent and measuring the impact on the should-cost this had. The result of this can be seen in table 5.1 below. It was discovered that the parameters influencing the production output had the largest impact, followed by the cost of raw material, depreciation time of equipment and the cost of debt. It is important to acknowledge that a 10 percent increase for all included parameters does not necessarily have the same effect on all cost factors. For example, a 10 percent increase in depreciation years is not equal to a 10 percent increase in slitting operators. However, this type of analysis still provides an indication of which parameters are the most noticeable when considering the final cost.

Table 5.1: Most impactful cost drivers in the should-cost model

Cost Driver	Impact (%)
Theoretical capacity (tons/year)	-4,784
Desired foil width (mm)	-4,186
Raw material foil stock ($/kg)	4,132
Working days (#)	-3,561
Depreciation equipment (years)	-2,202

This type of analysis is crucial to foster a better understanding of which production aspects correspond to the largest impact on the final cost. This allows the user to identify where in the production the most potential for price reduction exists. By partnering with the supplier this knowledge can enable both parties to reduce costs.

The identified cost impact of depreciation is mostly due to the large amount of investments necessary to produce cathode foil. This could be one explanation to why there are so few players in foil production, where the required funds are too overwhelming. This is despite the supply and demand dynamic being in favor of the producer, as highlighted in the capacity analysis.

5.5.3 Future improvements

Once the model's parameters and calculations have been validated, the next step for improvement is to access accurate and realistic data. The model is only going to be as accurate as the data is, meaning that accessing supplier production information is key for accuracy. However, this information is in most cases highly classified, unless the supplier is in close collaboration with the customer. By iteratively identifying key production values, the model is going to get more and more accurate. It is important to acknowledge that these key values may differ between supplier and supplier, whereas some values could act as a general benchmark and some values necessitate tweaking depending on which supplier is being analyzed.

Another field for improvement is versatility. As of now, the model is solely applicable to the process of producing aluminum foil, whereas flexibility to apply the model to other commodities is desirable to foster negotiation leverage throughout the entire procurement organ. This could be done by copying the methodology of the model and adapting the parameters and calculations to align with the processes and cost factors of the applied commodity. Another strategy could be to apply more generality to the model by adding more options and features which allow the user to switch between commodities.

5.6 Contribution to Northvolt

This section aims to analyze the contribution of the capacity analysis and the should-cost model based on the qualitative data gathered from the interviews described in section 4.3.

5.6.1 Contribution of analyzing the capacity

Capacity analysis provides substantial value by confirming hypotheses, identifying potential suppliers and risks, and laying a foundational understanding of market dynamics. Its applicability and relevance depend on several critical factors: product complexity, supply volume, and the geographic or market scope. To justify the investment of time in constructing a capacity, carbon offsets, and demand analysis, it is crucial that the product is standardized and could potentially be procured from multiple sources. There is a positive correlation between the standardization of a product and the availability of suppliers, whereas if one is achieved the other one is in general achieved as well. Additionally, the relevance of the analysis is enhanced when focused on a specific region, as demonstrated in this thesis which targeted North America. This regional focus aligns with Northvolt's preference for a local supply chain, naturally limiting the pool of relevant suppliers.

In Northvolt's scenario, the narrow product portfolio simplifies the diversity of supply needed, facilitating a strategy-driven sourcing approach where tools like capacity analysis are both justifiable and effective. Since establishing long-term relationships with suppliers is a priority, the supplier selection process is particularly crucial. The contracted price, quality, service, and environmental ambitions throughout the supply chain will significantly impact Northvolt's long-term performance. When executed effectively, capacity analysis forms a robust foundation for supplier selection, enabling comparisons and benchmarking to pinpoint suppliers that best align with the company's strategic goals. It was discovered that the capacity analysis is best carried out as an iterative process, where the data included is regularly checked and updated to make sure the values are realistic to the present market. Updating the analysis requires less work compared to the initial creation. By maintaining the relevancy of the analysis, it could be used to validate the contracted supplier's values on a regular basis.

Regarding the contracting phase in the procurement process, the capacity analysis offers little value. The analysis is rather applied to the earlier phases of the process, where the selection of supplier is most significant. One could, however, argue that capacity analysis provides benchmark data which could be applied to negotiations and thus, also contracting.

5.6.2 Should-cost applicability at Northvolt

The analysis of the should-cost model specific to this thesis gave insights and confirmation that is has value for the procurement of aluminum foil at Northvolt, but with the help of interviews with other category managers at Northvolt further insights in the model's applicability can be analyzed. These insights include how Northvolt's purchasing structure and strategy supports the use of the model, how the model can help category managers achieve their goals, for which categories the model can be applied to, and what to keep in mind when contemplating whether to implement the model.

Procurement structure alignment with should-costing

As previously stated, Northvolt has a centralized strategic purchasing unit with a category management system supporting tactical and operational decisions. According to the interviewed managers, category management is the obvious choice in Northvolt's situation and has enabled them to supply the products and components necessary. This is due to the volumes, complexity, design specifications and so forth of the purchased products. This structure and strategy have also proved to be beneficial for the creation of should-cost models. To create a should-cost model for a product or category, detailed and extensive knowledge of the products or category's cost drivers is required to create an accurate representation of the cost. According to the category managers, breaking down and understanding cost drivers and activities of the purchased product is something that is common practice and encouraged by higher management. This is also aligned with Ellram's findings in her report (2002). Therefore, creating a should-cost model should, theoretically, be possible to do for every category manager at Northvolt. Moreover, this encouragement of analyzing cost driver comes partly from the CEO and founder, Peter Carlsson, who has had an intense career within supply chain management and believes that this aspect is a large driver for success at Northvolt. Integrating more and more strategic cost management is something that has not been done previously, but some of the interviewees believe that it will play a larger role for them in the future.

Specific value and contribution identified by interviewees

Northvolt's procurement system supports the creation, use and implementation of should-cost modelling, but the question of why the supply chain organization should implement this model needs to be analyzed as well. The interviewees praised the value of this model and expressed that they would like it integrated into their day-to-day work. Most of the value they identified is in regard to negotiations and contracting, but of course also to supplier selection. Firstly, the contributions to negotiations and contracting include setting cost benchmarks, challenging suppliers' quotes, understanding the suppliers' margins and better understanding the cost structure of the category. Secondly, the contributions to the supplier selection process include comparing costs between suppliers, understanding how production capacity effects the costs at different suppliers, and differences in cost depending on where in the world the suppliers' production is located. In addition to the contribution within the thesis' scope, the category managers also identified contributions to other stages of the purchasing process, mainly the evaluation stage. In this stage the should-cost model can help with two activities: evaluating supplier performance which currently is conducted with the help of Analytic Hierarchy Process (AHP) analysis and identifying improvement areas in the supplier's production and supply chain. It is interesting to note that many of the contributions listed in regard to supplier selection, contracting and evaluation have also been identified in Ellram's article (2002). There are however new contributions and reasons for using this model that will be explained in section 6.3.

Relevant situations and categories in which to integrate the model

Lastly, even though integrating a should-cost model into each category might be tempting, it is wise to consider some important factors beforehand. In the literature review, it was recommended that the strategic and leverage items should be chosen for should-cost analysis. These two have the largest financial impact on a firm. However, the interviewed category managers claims that it is more relevant to consider factors regarding standardization of the item, complexity and specific design to Northvolt. For example, the category regarding separators in the battery is a relatively standardized product and therefore has a relatively standardized production process. The should-cost model will therefore be generalizable for different suppliers and markets. On the other hand, in the category regarding chemicals, Northvolt and the supplier together develop a recipe for the chemical composition that goes into the solvent in the battery. The production process is going to be different among suppliers and therefore not as generalizable. Deciding whether or not to implement a should-cost model on a category is not self-evident and is unfortunately not part of the scope for this thesis. However, these deciding factors mentioned is a good start, but will require more research to create a general decision framework.

5.7 Analysis and data quality discussions

This section aims to discuss the relationship between the capacity analysis and the should-cost model as well as the data quality in the different deliverables and interviews.

5.7.1 Discussion of the relationship between capacity analysis and should-cost

This thesis has researched on the contribution and use of a capacity analysis and the creation of a should-cost model. Because of this it is interesting to reflect on the relationship between these two analyses. Through the findings we can draw the conclusion that these two analyses do not share a definite relationship. The use of one analysis does not warrant or demand the use of the other. However, they can complement each other, which was proved in this thesis. As previously stated, there is a deficit of North American manufacturers of cathode foil even though there is a healthy production of primary aluminum. A possible answer can be drawn with the help of the weight analysis which proved that equipment, buildings, and land requires substantial investments. As the EV battery market is relatively new, there needs to be clear incentives for companies to invest in this industry.

5.7.2 Quantitative data from the capacity analysis

Data quality is an important factor to consider when using capacity analysis. The relevance of the analysis is heavily dictated by the reliability of the values. The quality of the data is especially important for the final two production stages. This is because of the calculation for the total capacity. Total capacity for bauxite, alumina and primary aluminum could be gathered from reliable sources, however there were no sources for foil stock and thin aluminum foil in North America. Instead, the capacity for aluminum foil stock and thin foil were assumed to be the same as the total capacity for the suppliers that operate in these two parts of the value chain. However, after confirmation from Northvolt, the total capacity of thin aluminum foil is known to be low, and the only relevant suppliers are the ones presented in this stage in chapter 4. This tells us that the estimated capacity is relatively reliable. Furthermore, the total capacity for foil stock and respective suppliers are not known to Northvolt. The total capacity cannot therefore be confirmed, which lowers data quality. This value is, however, not as important to Northvolt as the total capacity for thin foil and is mainly used to assist in illustrating, for example, bottlenecks in the production process in North America.

Regarding the individual capacity values for each supplier, they vary in quality. As presented in table 4.2, each value has been highlighted green, yellow, or red depending on reliability. Important to note here that the value for thin foil capacity is marked green which highlights its quality and usefulness of the analysis for Northvolt. Moreover, each value regarding GHG emissions for each supplier are all marked green as each number is sourced from their sustainability report, if they have one. However, it can be discussed if their reporting is done correctly but is not relevant for this analysis and thesis.

Lastly, the values for demand in North America vary slightly in quality. Most of the data is sourced from either reliable news articles or company announcements. There are, however, news articles that state the information to be speculation which lowers the data quality. This is, on the other hand, not detrimental for the analysis as it is meant to present the maximum demand over the years to come.

5.7.3 Quantitative data from the should-cost model

Regarding the should-cost model, validation and data quality plays a large role. However, it can be argued that validation is more important than data quality. This is because validation must be conducted several times to ensure that all relevant cost drivers are included and that all cost models are correctly calculated. This is to verify that the model gives a reasonable and reliable estimation of the should-cost. If validation is not done correctly, the model will give a bad estimation of the should-cost no matter how high the quality of the data is. The validation process of the model was conducted with the help of two workshops with different audiences. The first workshop was conducted with Northvolt's aluminum foil expert and category manager for foils, and the purpose was to improve the structure of the model, ensure all relevant aspects and cost drivers were included, and cost models were correctly calculated. The second workshop was held with an expert in cost analysis and category manager for foils, and the purpose was to conduct a final validation check of the model.

Data quality is, as mentioned, also important for the model, but the responsibility for this will lie on the user of the model. This is because the model will work best with data that has been gathered from one supplier to be analyzed on that supplier. The data extracted from the supplier must be of high quality for the model to calculate a high-quality estimation of the should-cost. When the model is not using supplier-specific data, the model uses either standard or average data which originates from public databases, internal Northvolt documents or from the aluminum foil expert's estimations. Public database values have been extracted for each country and state that the model has included. For example, the average blue collar worker's salary and cost of electricity for each state has been included. For internal Northvolt documents and estimations from the expert in aluminum foil, these work as standard values and do not change depending on which country and state is specified. Therefore, regarding data quality, the public database values are of relatively high quality and have been triangulated with several sources to ensure this. However, the data is not specific to a supplier and will therefore be worse than data extracted from a supplier. Internal Northvolt documents are of high quality as well but cannot be triangulated against any other data. Lastly, estimations based on personal insight and experience are in general not of high reliability, especially in this case where there are no benchmark values. However, due to Northvolt's aluminum expert's expertise, long-term insight and firsthand experience in this industry, the data and estimations provided by him is considered reliable. The data these three sources provide is useful to give a general should-cost of aluminum foil in North America, but most only act as a placeholder until more specific data towards a supplier can take its place.

5.7.4 Qualitative data from the interviews

As the interviewees participating in this thesis belong to the same company, with the majority having similar titles and backgrounds, one could argue that the qualitative data gathering suffers from organizational or personal bias. However, as the content of the interview questions are non-related to performance, the risk of bias becomes insignificant. The interviewees have nothing to gain from withholding the truth, whereas the opposite allows for an in-depth analysis which aims to provide valuable information to their organization. Thus, it is concluded that the risk of bias is negligible. However, it would be beneficial to include interviews with relevant professionals operating at other companies, to see if the opinions are shared throughout the field of procurement and not just at Northvolt.

An improvement to the qualitative data collection would be to include more interviews, from a broader range of perspectives and occupations. However, since the thesis aims to answer questions related to the processes of procurement, the category managers are in this case deemed most relevant to the research. The quality would, however, become more reliable if the number of interviewees increased.

6 Conclusion

This section concludes the thesis by answering the research question and summarizing the concluding thoughts. Apart from aligning with the purpose of the study, the contribution to the case company and to academic research will be discussed along with a reflection regarding the thesis process.

The purpose of the thesis was the following: the purpose of this master's thesis is to conduct a capacity analysis and develop a should-cost model and analyze their respective contribution to the procurement processes of selecting suppliers and contracting.

6.4 Implications of the study

The purpose of the study corresponds to one research question, which in turn necessitates two research objectives to be fulfilled before being answered. The first research objective was to:

> **RO1:** Conduct a capacity analysis of the aluminum foil market in North America, which includes:
> i. Current and future supply of aluminum foil
> ii. Corresponding carbon offset and environmental goals for the future
> iii. Projected demand of battery cathode foil

To measure the contribution a capacity analysis offers to the procurement processes, the actual analysis had to be conducted. In this case, the analysis included supply capacity, corresponding carbon emissions and environmental ambitions for the present and future, and projected demand. The study highlighted a discrepancy between the producers across the value chain regarding GHG emissions. The shortage of cathode foil is another important finding by the analysis, where the customers of foil heavily outnumber the relevant local suppliers.

The second research objective to be accomplished was the following:

> **RO2:** Create a should-cost model which aims to estimate the cost to produce aluminum foil for tier 1 suppliers.

The model, constructed in Excel, combines theoretical insights regarding the aluminum foil production process and the principles of strategic cost management, both of which derive from the literature review. Through multiple validation sessions and benchmarking data, the model is concluded to be sufficient regarding its accuracy of estimating the cost of cathode foil production. As desired, the model allows for both generality and specificality, depending on the user's access to relevant supplier data.

Once these two objectives were accomplished, the remaining task was to answer the research question, which was the following:

> **RQ:** How could a capacity analysis and should-cost model contribute to the supplier selection and negotiation processes of Northvolt?

To assess this question, the need for qualitative data was apparent. This was carried out by conducting five structured interview sessions with category managers at Northvolt. These interviews had the purpose to understand their purpose to Northvolt's procurement strategy, their view on Northvolt's procurement structure and strategy, and their familiarity and opinions of the two deliverables.

It was concluded that a capacity analysis and a should-costing model offer great value, when applicable, to the process of selecting suppliers. Whether the relevance of application exists is highly connected to the complexity of the product and supply market. When successfully constructed, the capacity analysis provides a foundation for identifying suitable suppliers. This is in terms of capacity and environmental ambitions, which are both crucial to the operations of Northvolt. It also gives an indication of the dynamic of the market in the future, which assists in assessing the potential risks of entering the market.

The should-costing model provides understanding of where in the production process the contracted or potential suppliers are most impacted regarding the cost. This allows Northvolt to apply suitable strategies in terms of supplier selection and negotiations. This could be achieved either by identifying inflated supplier prices and requesting reductions, or through collaboration between Northvolt and its suppliers aimed at lowering production costs to secure price reductions. As with the capacity analysis, should-costing analysis, and modelling benefits from standardization, in this case of the production process in the industry. When successfully carried out, it offers great insights and leverage which assists in both the supplier selection phase, the negotiation phase, and the evaluation phase.

6.5 Contribution to the case company

As previously mentioned, this master thesis has contributed both to the case company and to academia. There are several practical applications that were conceived and analyzed through literature review, empirics gathering and analysis. The conclusions will be divided into two parts describing the practical contributions of the capacity analysis and the should-cost model had to Northvolt respectively. Both sections will describe what insights were gathered from analysis of both models and what value the interviewed category managers could identify.

6.5.1 Specific and general contributions of the capacity analysis

Firstly, the capacity analysis contributed to mapping the current and future situation of the North American aluminum foil market. This analysis has value as no information on this market had yet been gathered and analyzed ahead of the opening of Northvolt's new factory in Montreal, Canada. As a result, the following conclusion was drawn from the analysis:

- Several players in the industry have acceptable GHG emissions within Northvolt's policy.
- All players in the value chain have set up the same goals and ambitions to reduce carbon emissions, for example to reduce scope 1+2+3 emissions by 30% by 2030 and to become carbon neutral by 2050.
- The EV battery manufacturing industry sees large growth in the future, however the same growth in locally manufactured aluminum does not see this same growth. Currently only two companies manufacture dedicated battery cathode foil. Existing and future factories must rely on either imported foil from Asia or the hope the competition in North America will increase.
- Lastly, even though we see a shortage of locally manufactured aluminum foil in North America, we can observe a large production of primary aluminum. There are therefore possibilities for new players to enter this market and reap the benefits of the growing EV battery market.

In addition to the actual analysis of the capacity in North America, interviews were conducted with Northvolt category managers to understand how a capacity analysis can contribute to any category at any company. An analysis of the answers concluded into the following insights:

- Capacity analysis provides substantial value by confirming hypotheses, identifying potential suppliers and risks, and laying a foundational understanding of market dynamics.
- Its applicability and relevance depend on several critical factors: product complexity, supply volume, number of suppliers, and the geographic or market scope.
- Northvolt highly values long-term partnerships with its suppliers, which is why investing resources into such analysis can create a strong foundation for their supplier selection processes.

To conclude, the capacity analysis that this thesis has produced provided valuable insights into the North American aluminum foil market that Northvolt can utilize ahead of the opening of their new factory. Additionally, through interviews with several category managers at Northvolt, we could provide specific contributions that a capacity analysis can give to a general category and in which cases it is relevant to implement.

6.5.2 Specific and general contributions from the should-cost model

Secondly, regarding the created should-cost model, several practical applications have been identified through self-conducted analysis of the model and through interviews with category managers at Northvolt. The identified contributions and application of the model are summarized below:

- Cost comparisons
- Weight analysis
- Setting benchmarks
- Challenging suppliers' quotes
- Understanding suppliers' margins
- Understanding the cost structure of the category and product
- Understanding how production capacity effects the costs at different suppliers
- Understanding differences in cost depending on geographic location
- Supplier evaluation beyond AHP

In addition to the contributions, some analysis and insights were gathered regarding which situations and for which categories this type of analysis is relevant for. Previously, the theory was that leverage and strategic products are the most relevant, however according to the interviewees, it is about how complex the production process of the product is and the specificity of the product to the purchaser. If the product is too complex and too specific for Northvolt, it becomes increasingly difficult to conduct such an analysis and therefore begs the question if it is worth it or not. However, this question was not the main question of the thesis and therefore more research must be conducted to precisely dictate which situations invite the creation of a should-cost analysis.

Moreover, the model created by this thesis has already been used to compare prices between suppliers with operations in North America and Europe, and to challenge European supplier quotes ahead of new negotiations. In conclusion, the listed contributions and the fact that it is already in use proves its broad utilization and generalization of the model. It can add great value in the day-to-day work in several categories and companies.

6.6 Contribution to academics

This thesis has made several academic contributions that surrounds the use of capacity analysis and should-cost analysis, but also connecting purchasing strategy and purchasing structure to these models. Firstly, regarding the purchasing structure in a company, it was discovered that creating a should-cost model requires a deep understanding of the product being analyzed on. Therefore, adopting a category management purchasing system, which Northvolt has, greatly streamlines the process of creating the model. This relationship between purchasing structure and cost models within strategic cost management is not something that has previously been researched on.

Secondly, this thesis has added reasons and contributions that the should-cost model can give to a firm. Much of what was discovered regarding the contribution is in line with what Ellram (2002) discovered in her research regarding the model. However, this thesis also discovered several additional factors that increase the value of the model, including:

- The should-cost model can increase the understanding of how a supplier's capacity affects the price of a product.
- The model can describe how the geographic location of where the product is manufactured affects price.
- The model can facilitate the creation of a weight analysis that can illustrate which cost drivers in production affect the cost the most.

Thirdly, some analysis has been conducted on when to implement a should-cost analysis. This is something that has not been researched previously. This was, however, not initially part of the scope for the thesis but awoken curiosity regarding the answer. The data gathered in this thesis pointed to the fact that the complexity of the product and production process as well as the specificity of the product towards the purchaser are the deciding factors. The initial hypothesis was only connected to the financial impact of the purchased product.

The fourth academic contribution is regarding the use of capacity analysis. Similarly to the use of the should-cost model, the findings of the thesis indicate that the standardization of the product being analyzed on. In other words, a product such as aluminum foil is more relevant to analyze than a specific chemical recipe for the electrolyte solution for a Northvolt battery.

6.7 Limitations and future research

The capacity analysis was in this case limited to the North American market, which is aligned with Northvolt's preference of local supply and the emerge of Northvolt Six. For academic purposes, it would be of interest to conduct a similar analysis on a global scale. This would assist in explaining the shortage of supply in the North American market, as imports from Asian countries is, as mentioned, the likely cause. Another interesting aspect of this would be to analyze the discrepancies regarding carbon footprint between suppliers across the globe. This would provide insights to where and why the average emission per kilogram of aluminum foil produced is significantly larger than in North America. Regarding the should-costing model, it would be relevant to include the entire value chain. This would give insight to where in the chain most value is added, thus, where in the process most cost is required. However, to conduct such a study, a significant amount of supplier data is required to provide estimates with sufficient accuracy. Another field for future research is to analyze which categories are the most suitable for application of similar research. In this thesis, the complexity of the product and market is concluded to be of significance. However, there are most likely many more factors to consider.

6.8 Thesis reflection

To conclude the thesis, we would like to reflect on our process and learnings during the study. To conduct the two deliverables, our theoretical and practical knowledge have consistently been challenged and improved. During the literature review we gained specific knowledge regarding procurement and the process of making aluminum foil. This part of the process proved to be critical to the following analytics and research.

During the construction of the capacity analysis, the availability of information varied significantly between the included companies. For some, the relevant data were publicly published, whereas some required estimates and calculations. Regarding the should-costing model and the process of building it, it was highly iterative. Through numerous validation sessions, many functions and parameters were replaced and altered. By the end, the model is in line with both our and the case company's vision regarding usability and accuracy.

It has been challenging to stay within the scope and align the analysis with the purpose of thesis, whereas many reflections and check-ups were required to maintain the red line. Apart from this, another challenge was to maintain the value to the case company while also providing contributions to the academy. By staying in close collaboration with our supervisors, both at LTH and at Northvolt, throughout the process, this challenge was successfully managed.

It has been fascinating to work in collaboration with Northvolt and assisting them in their entrance to the North American market. This company is fast-paced and innovative, aligning well with our own working philosophies.

7 Bibliography

Achenbach, n.d.. *Achenbach Optifoil Rewinder.* [Online]
Available at: https://www.achenbach.de/en/machines-equipment/optifoil-foil-slitting-machines/optifoil-rewinder/
[Accessed 19 February 2024].

Achenbach, n.d.. *Achenbach Optimill Foil Rolling Mills.* [Online]
Available at: https://www.achenbach.de/en/machines-equipment/optimill-rolling-mills/optimill-foil-rolling-mills/
[Accessed 16 February 2024].

Alamalhodaei, A., 2021. *Solid Power expands production capacity to deliver test batteries to BMW, Ford in 2022.* [Online]
Available at: https://techcrunch.com/2021/09/07/solid-power-expands-production-capacity-to-deliver-test-batteries-to-bmw-ford-in-2022/
[Accessed 26 March 2024].

Alcoa, 2023. *2022 Annual Report.* [Online]
Available at: https://s29.q4cdn.com/945634774/files/doc_financials/2022/ar/Alcoa-Corp-2022-Annual-Report-Final-Bookmarked.pdf
[Accessed 12 March 2024].

Alcoa, n.d.. *Products.* [Online]
Available at: https://www.alcoa.com/global/en/what-we-do
[Accessed 19 February 2024].

Alcoa, n.d.. *Sustana™: Alcoa's low carbon aluminum solutions.* [Online]
Available at: https://www.alcoa.com/products/sustana
[Accessed 12 March 2024].

Almexa, n.d.. *About.* [Online]
Available at: https://www.almexa.com.mx/about/
[Accessed 10 April 2024].

Aluminum foil expert, 2024. *Input and feedback on inital structure of capacity and should-cost model* [Interview] (04 March 2024).

American Battery Factory, n.d.. *Domestic Production.* [Online]
Available at: https://americanbatteryfactory.com/production
[Accessed 26 March 2024].

American Battery Solutions, n.d.. *Our Facilities.* [Online]
Available at: https://www.americanbatterysolutions.com/facilities
[Accessed 26 March 2024].

Amprius, 2023. *Amprius Technologies Selects Colorado for Gigawatt-Hour Scale Factory Site.* [Online]
Available at: https://amprius.com/amprius-technologies-selects-colorado-for-gigawatt-hour-scale-factory-site/
[Accessed 26 March 2024].

Arconic, 2022. *2022 Annual Report.* [Online]
Available at: https://www.arconic.com/documents/42106/97639/2022-Arconic-Annual-Report.pdf
[Accessed 13 March 2024].

Arconic, 2022. *2022 Sustainability Report.* [Online]
Available at: https://www.arconic.com/documents/d/arconic/arconic-2022-esg-report
[Accessed 13 March 2024].

Aronic, n.d.. *About us.* [Online]
Available at: https://www.arconic.com/about-us
[Accessed 10 April 2024].

Arruda, C., Clark, A. & Landale, K., 2019. Implementing category management of services - a new methodology. *Journal of Public Procurement,* 19(2), pp. 165-183. DOI: 10.1108/JOPP-03-2018-0012.

Atalco, n.d.. *About.* [Online]
Available at: https://www.atalco.com/#about
[Accessed 10 April 2024].

Atalco, n.d.. *The last operating.* [Online]
Available at: https://www.atalco.com/#sec
[Accessed 11 March 2024].

Bäckstrand, J., Suurmond, R., van Raaij, E. & Chen, C., 2019. Purchasing process models: Inspiration for teaching purchasing and supply management. *Journal of Purchasing and Supply Management,* 25(5. DOI: 10.1016/j.pursup.2019.100577).

Barten, A. E., 2002. *Aluminium Rolling Mill Technology: Future concepts in Thin-strip and Foil Rolling.* 233 ed. s.l.:Verlag Moderne Industrie.

Björklund, M. & Paulsson, U., 2012. *Seminarieboken: att skriva, presentera och opponera.* 2nd ed. s.l.:Studentlitteratur.

Category manager 1, 2024. *Category manager for the electrical segment* [Interview] (22 April 2024).

Category manager 2, 2024. *Category manager for seperators* [Interview] (22 April 2024).

Category manager 3, 2024. *Category manager for chemicals* [Interview] (22 April 2024).

Category manager 4, 2024. *Category manager for foils* [Interview] (24 April 2024).

Century Aluminum, 2023. *2022 Sustainability Report.* [Online]
Available at: https://gri.centuryaluminum.com/wp-content/uploads/2023/08/CA_Sustainability_Report_2022.pdf
[Accessed 12 March 2024].

Century Aluminum, n.d.. *Company at a glance.* [Online]
Available at: https://centuryaluminum.com/company/company-glance/default.aspx
[Accessed 10 April 2024].

Century Aluminum, n.d.. *U.S. billet supplier and growing scrap reprocessing capabilities.* [Online]
Available at: https://centuryaluminum.com/products-and-plants/sebree-ky/default.aspx
[Accessed 12 March 2024].

Century Aluminum, n.d.. *Unearthing value and supporting sustainability.* [Online]
Available at: https://centuryaluminum.com/products-and-plants/Jamalco-Jamaica/default.aspx
[Accessed 12 March 2024].

Constellium, 2023. *2022 Annual Report.* [Online]
Available at:
https://res.cloudinary.com/constellium/image/upload/v1678796661/PDF%20documents/Annual%20and%20Interim%20Reports/2022_-_20-F_AS_FILED_03.14.23_fekhky.pdf
[Accessed 12 March 2024].

Constellium, 2023. *Sustainability Report 2023.* [Online]
Available at:
https://res.cloudinary.com/constellium/image/upload/v1710845486/PDF%20documents/Brochures%20and%20Reports/Business%20and%20Sustainability%20Reports/Reports%202024/2023_Constellium_Sustainability_Report_English.pdf
[Accessed 12 March 2024].

Constellium, n.d.. *About.* [Online]
Available at: https://www.constellium.com/about-us
[Accessed 10 April 2024].

Cost analysis expert, 2024. *Senior Manager purchasing* [Interview] (22 April 2024).

Curtolo, D. C., Xiong, N., Friedrich, S. & Friedrich, B., 2021. High- and Ultra-High-Purity Aluminium, a review on Technical Production Methodologies. *Metals,* 11(9), p. DOI: 10.3390/met11091407.

Director of Purchasing, 2024. *Director of Purchasing Chemicals and Components* [Interview] (19 April 2024).

Donoghue, A. M., Frisch, N. & Olney, D., 2014. Bauxite Mining and Alumina Refining. *Journal of Occupation and Environmental Medicine,* Volume 56, pp. 12-17. DOI: 10.1097/JOM.0000000000000001.

Dr. Ernst, S., 2023. *Volkswagen-backed PowerCo SE reaches significant milestone in St. Thomas gigafactory project.* [Online]
Available at: https://www.volkswagen-group.com/en/press-releases/volkswagen-backed-powerco-se-reaches-significant-milestone-in-st-thomas-gigafactory-project-17962
[Accessed 26 March 2024].

Eisenhardt, K. M., 1989. Building theories from case study research. *The Academy of Management Review,* 14(4), pp. 532-550. DOI: 10.2307/258557.

Electricity Local, n.d.. *Local Electricity Information & Resources.* [Online]
Available at: https://www.electricitylocal.com/
[Accessed 3 April 2024].

Electrovaya , 2022. *Electrovaya to Establish Lithium-Ion Gigafactory in New York State.* [Online]
Available at: https://electrovaya.com/press/electrovaya-to-establish-lithium-ion-gigafactory-in-new-york-state/
[Accessed 26 March 2024].

Ellram, L. M., 2002. *Strategic Cost Management in the Supply Chain: A Purchasing and Supply Management Perspective,* s.l.: Center for Advanced Purchasing Studies.

Fischer, A., 2022. *FREYR plans the Giga America lithium-ion battery manufacturing facility in Georgia.* [Online]
Available at: https://pv-magazine-usa.com/2022/11/11/freyr-plans-the-giga-america-lithium-ion-battery-manufacturing-facility-in-georgia/
[Accessed 26 April 2024].

Ford, 2023. *FORD TAPS MICHIGAN FOR NEW LFP BATTERY PLANT; NEW BATTERY CHEMISTRY OFFERS CUSTOMERS VALUE, DURABILITY, FAST CHARGING, CREATES 2,500 MORE NEW AMERICAN JOBS.* [Online]
Available at: https://media.ford.com/content/fordmedia/fna/us/en/news/2023/02/13/ford-taps-michigan-for-new-lfp-battery-plant--new-battery-chemis.html
[Accessed 26 March 2924].

Freyr Battery, 2021. *FREYR Announces Joint Venture with Koch Strategic Platforms to Advance Development of Clean Battery Cell Manufacturing in the United States.* [Online]
Available at: https://www.freyrbattery.com/news/freyr-announces-joint-venture-with-koch-strategic-platforms-to-advance-development-of-clean-battery-cell-manufacturing-in-the-united-states
[Accessed 26 March 2024].

GM Authority, n.d.. *GM New Carlisle, Indiana Battery Plant.* [Online]
Available at: https://gmauthority.com/blog/gm/gm-facilities/ultium-cells-battery-plants-global/ultium-cells-usa-battery-plants/gm-new-carlisle-indiana-battery-plant/
[Accessed 26 March 2024].

Gränges, 2023. *Annual and Sustainability report 2022.* [Online]
Available at: https://www.granges.com/globalassets/05.-investerare/04.-rapporter-och-presentationer/2023/02-annual-report-2022/granges_annual_and_sustainability_report_2022.pdf
[Accessed 12 March 2024].

Gränges, n.d.. *About Gränges.* [Online]
Available at: https://www.granges.com/about-granges/
[Accessed 10 April 2024].

Green Car Congress, 2022. *LG Energy Solution building $1.4B, 11 GWh gigafactory in Arizona.* [Online]
Available at: https://www.greencarcongress.com/2022/03/20220329-lges.html
[Accessed 26 March 2024].

Han, Y. et al., 2012. Effect of hot rolling temperature on grain size and precipitation hardening in a Ti-microalloyed low-carbon martensitic steel. *Materials Science and Engineering,* Volume 533, pp. 192-199. DOI: 10.1016/j.msea.2012.06.015.

Haupin, W. E., Bearne, G., Dupuis, M. & Tarcy, G., 1995. Principles of Aluminum Electrolysis. *Essential Readings in Light Metals,* Volume 2, pp. 3-11. DOI: 10.1007/978-3-319-48156-2_1.

Hedsand, M. & Aluminum foil expert, 2024. *Workshop on the structure of the should-cost analysis* [Interview] (04 April 2024).

Hind, A. R., Bhargava, S. K. & Grocott, S. C., 1998. The surface chemistry of Bayer process solids: a review. *Colloids and Surfaces: A Physiochemical and Engineering Aspects,* 146(1-3), pp. 359-374. DOI: 10.1016/S0927-7757(98)00798-5.

Honda, 2023. *Honda Announces Next Steps in Preparation for U.S. EV Production.* [Online]
Available at: https://hondanews.com/en-US/releases/honda-announces-next-steps-in-preparation-for-us-ev-production
[Accessed 26 March 2024].

Hydro, n.d.. *Aluminium for distributors.* [Online]
Available at: https://www.hydro.com/en-US/aluminum/industries/distribution/
[Accessed 19 February 2024].

Jarratt, E., 2021. *StromVolt unveils "mission" to build Canada's first large-scale EV battery cell manufacturing plant.* [Online]
Available at: https://electricautonomy.ca/ev-supply-chain/batteries/2021-10-05/stromvolt-battery-cell-manufacturer-qc/
[Accessed 26 March 2024].

Jill, 2023. *What Is The Average Salary In Canada 2023 (By Province & Job Type)?.* [Online]
Available at: https://britsincanada.ca/what-is-the-average-salary-in-canada-by-province-job-type/
[Accessed 3 April 2024].

Johnson, P., 2023. *Hyundai and SK On finalize $5B US battery factory [Update].* [Online]
Available at: https://electrek.co/2023/04/25/hyundai-and-sk-on-finalize-5b-us-battery-factory-update/
[Accessed 26 March 2024].

Kaiser Aluminum, n.d.. *Products.* [Online]
Available at: https://www.kaiseraluminum.com/products/
[Accessed 19 February 2024].

Kalpakjian, S., Schmid, S. R. & Vijay Sekar, K. S., 2023. *Manufacturing Engineering and Technology.* 8th ed. s.l.:Pearson Education Limited.

Kane, M., 2021. US: SK Innovation Announces Five Battery Plants And 150 GWh/Year. *Inside EVs.*

Kane, M., 2021. *US: SK Innovation Announces Five Battery Plants And 150 GWh/Year.* [Online]
Available at: https://insideevs.com/news/536883/us-sk-innovation-battery-150gwh/
[Accessed 26 March 2024].

Kane, M., 2022. *Envision AESC Announces $2 Billion Gigafactory In Kentucky.* [Online]
Available at: https://insideevs.com/news/580234/envision-aesc-2billion-gigafactory-kentucky/
[Accessed 26 March 2024].

Kane, M., 2022. *Envision AESC To Invest $810 Million In South Carolina Gigafactory.* [Online]
Available at: https://insideevs.com/news/627212/envision-aesc-810million-south-carolina-gigafactory/
[Accessed 26 March 2024].

Kane, M., 2022. *Report: CATL Might Build An 80 GWh Battery Plant In North America.* [Online]
Available at: https://insideevs.com/news/574564/catl-battery-plant-north-america/
[Accessed 26 March 2024].

Kane, M., 2023. *Hyundai And LGES To Invest Additional $2 Billion In Georgia.* [Online]
Available at: https://insideevs.com/news/685808/hyundai-lges-invest-additional-2billion-georgia/
[Accessed 26 March 2024].

Keteres, 2023. *Local Sourcing: How it Benefits the Environment, the Community, and Your Supply Chain.* [Online]
Available at: https://www.keteres.com/resource/what-is-local-sourcing
[Accessed 26 April 2024].

Kore Power, 2021. *Get ready Arizona the KOREPlex is landing.* [Online]
Available at: https://korepower.com/media/get-ready-arizona-the-koreplex-is-landing
[Accessed 26 March 2024].

Kousal, K. V., 2013. *Should-cost analysis a key tool for sourcing and product designers.* [Online]
Available at: https://www.quest-global.com/wp-content/uploads/2021/06/Should-Cost-Analysis-A-Key-Tool-for-Sourcing-and-Product-Designers.pdf
[Accessed 07 December 2023].

Lambert, F., 2022. *Tesla applies to build giant new cathode factory for battery production next to 'Gigafactory Texas'.* [Online]
Available at: https://electrek.co/2022/02/03/tesla-applies-build-giant-new-cathode-factory-battery-production-gigafactory-texas/
[Accessed 26 March 2024].

Landale, K. A. F., Apte, A. & Rendon, R. G., 2017. Using analytics to inform category management and strategic sourcing. *Journal of Defence Analytics and Logistics,* Volume 1, pp. 151-171. DOI: 10.1108/JDAL-06-2017-0010.

LG, 2023. *LG Energy Solution Michigan Inc. "Tops Out" New Production Facility.* [Online]
Available at: https://news.lgensol.com/company-news/press-releases/1760/
[Accessed 26 March 2024].

Lienert, P., Shepardson, D. & Klayman, B., 2021. *EXCLUSIVE Amazon-backed Rivian confirms plan for second U.S. assembly plant.* [Online]
Available at: https://www.reuters.com/business/autos-transportation/exclusive-amazon-backed-rivian-confirms-plan-second-us-assembly-plant-2021-07-22/
[Accessed 26 March 2024].

Lion Electric, 2023. *LION ELECTRIC INAUGURATES ITS BATTERY MANUFACTURING FACTORY FOR MEDIUM AND HEAVY-DUTY VEHICLES.* [Online]
Available at: https://ir.thelionelectric.com/English/news/news-details/2023/LION-ELECTRIC-INAUGURATES-ITS-BATTERY-MANUFACTURING-FACTORY-FOR-MEDIUM-AND-HEAVY-DUTY-VEHICLES/default.aspx
[Accessed 26 March 2024].

Lotte, n.d.. *About Lotte.* [Online]
Available at: https://www.lotte.co.kr/global/en/about/mission.do
[Accessed 10 April 2024].

Magnis, n.d.. *iM3NY Lithium-ion Battery Factory in New York.* [Online]
Available at: https://magnis.com.au/im3ny/
[Accessed 26 March 2024].

Manuj, I. & Mentzer, J. T., 2011. Global Supply Chain Risk Management. *Journal of Business Logistics,* Volume 29, pp. 133-135. DOI: 10.1002/j.2158-1592.2008.tb00072.x.

Mealer, C. M. & Park, S. H., 2013. *A Simplied and Scalable Should-Cost Tool in the Oilfield Services,* s.l.: Massachusetts Institute of Technology.

MINO, n.d. *PROCESS AND TECHNOLOGIES.* [Online]
Available at: https://mino.it/process-technologies/aluminium/
[Accessed 15 February 2024].

Min, S. et al., 2005. Supply chain collabortation: what's happening?. *International Journal of Logistics Management,* 16(2), pp. 237-256. DOI: 10.1108/09574090510634539.

Moloughney, T., 2023. *Ford's Future EV Mega Factory In Tennessee Begins Taking Shape.* [Online]
Available at: https://insideevs.com/news/658814/ford-blueoval-city-construction-undeway/
[Accessed 26 March 2024].

Natural Resources Canada, 2023. *Energy Fact Book,* s.l.: Natural Resources Canada. URL: https://energy-information.canada.ca/sites/default/files/2023-10/energy-factbook-2023-2024.pdf.

Norrman, A. & Olhager, J., 2023. Global Supply Chain Management. *The Palgrave Handbook of Supply Chain Management,* pp. 53-88. DOI: 10.1007/978-3-031-19884-7_100.

Northvolt, n.d. *We are Northvolt.* [Online]
Available at: https://northvolt.com/about/
[Accessed 6 March 2024].

Novelis, 2022. *Novelis Reports Fourth Quarter and Fiscal Year 2022 Results.* [Online]
Available at: https://investors.novelis.com/2022-05-11-Novelis-Reports-Fourth-Quarter-and-Fiscal-Year-2022-Results
[Accessed 12 March 2024].

Novelis, 2023. *2023 Sustainability Report.* [Online]
Available at: https://www.novelis.com/wp-content/uploads/2023/09/Novelis-Sustainability-Report-2023.pdf?utm_source=download&utm_medium=download&utm_campaign=sustainability_report_2023&utm_id=sustainability
[Accessed 12 March 2024].

Novelis, n.d.. *Our Company.* [Online]
Available at: https://www.novelis.com/about-us/
[Accessed 10 April 2024].

One, n.d.. *Manufacturing.* [Online]
Available at: https://one.ai/manufacturing
[Accessed 26 March 2024].

Panasonic, 2022. *Panasonic Energy Breaks Ground on EV Battery Factory in Kansas.* [Online]
Available at: https://na.panasonic.com/us/news/panasonic-energy-breaks-ground-ev-battery-factory-kansas
[Accessed 26 March 2024].

Parsa, D., 2019. *SHOULD-COST ANALYSIS AS AN ALTERNATIVE TO OPEN BOOK ACCOUNTING,* s.l.: Tempere University.

Ratvik, N. F., Schlaegel, C., Midgley, D. F. & Tressin, T., 2022. Aluminium production process: from Hall-Héroult to modern smelters. *ChemTexts,* 8(10), pp. DOI: 10.1007/s40828-022-00162-5.

Richter, N. F., Schlaegel, C., Midgley, D. F. & Tressin, T., 2019. Organizational structure characteristics' influences on international purchasing performance in different purchasing locations. *Journal of Purchasing and Supply Management,* 25(4. DOI: 10.1016/j.pursup.2018.12.001).

Rio Tinto, 2023. *Annual report.* [Online]
Available at: https://www.riotinto.com/en/invest/reports/annual-report
[Accessed 14 March 2024].

Rio Tinto, 2023. *Sustainability reporting.* [Online]
Available at: https://www.riotinto.com/en/invest/reports/sustainability-report
[Accessed 11 March 2024].

Rio Tinto, 2024. *Production.* [Online]
Available at: https://www.riotinto.com/en/invest/financial-news-performance/production
[Accessed 11 March 2024].

Rio Tinto, n.d.. *Our Business.* [Online]
Available at: https://www.riotinto.com/en/about/our-business
[Accessed 10 April 2024].

Rounaghi, M. M., Jarrar, H. & Dana, L. P., 2021. Implementation of strategic cost management in manufacturing companies: overcoming costs stickiness and increasing corporate sustainability. *Future Business Journal,* Volume 7, pp. 1-8. DOI: 10.1186/s43093-021-00079-4.

Sakuu, 2022. *Sakuu Opens New Battery Printing and Engineering Facility in Silicon Valley.* [Online]
Available at: https://www.sakuu.com/news/sakuu-opens-new-battery-printing-and-engineering-f
[Accessed 26 March 2024].

Saunders, M., Lewis, P. & Thornhill, A., 2006. *Reserach methods for business students.* 4th ed. s.l.:Peason Prentice Hall.

Selveira, F. & Morgan, S., 2023. *Stellantis, Samsung SDI Announce Plans to Build Second StarPlus Energy Gigafactory in the United States.* [Online]
Available at: https://www.stellantis.com/en/news/press-releases/2023/july/stellantis-samsung-sdi-announce-plans-to-build-second-starplus-energy-gigafactory-in-the-united-states
[Accessed 26 March 2024].

Sengupta, D., 2023. *Update: Top five aluminum foil manufactureres in the United States.* [Online]
Available at: https://www.alcircle.com/news/update-top-five-aluminium-foil-manufacturers-in-the-united-states-98995
[Accessed 19 February 2024].

Shepardson, D. & Lienert, P., 2022. *EV battery makers Gotion, ONE plan new Michigan plants.* [Online]
Available at: https://www.reuters.com/business/autos-transportation/ev-battery-makers-gotion-one-plan-new-michigan-plants-2022-10-05/
[Accessed 26 March 2024].

Silveira, F. & Morgan, S., 2022. *Stellantis and LG Energy Solution to Invest Over $5 Billion CAD in Joint Venture for First Large Scale Lithium-Ion Battery Production Plant in Canada.* [Online]
Available at: https://www.stellantis.com/en/news/press-releases/2022/march/stellantis-and-lg-energy-solution-to-invest-over-5-billion-cad-in-joint-venture-for-first-large-scale-lithium-Ion-battery-production-plant-in-canada
[Accessed 26 March 2024].

Statevolt, n.d.. *Imperial Valley Gigafactory.* [Online]
Available at: https://statevolt.com/manufacturing/imperial-valley-gigafactory/
[Accessed 26 March 2024].

Team Kentucky, 2022. *LOTTE Group to Locate $238.7 Million Facility in Elizabethtown, Create 122 Jobs to Serve EV Sector.* [Online]
Available at: https://ced.ky.gov/Newsroom/NewsPage/20220804_LOTTE
[Accessed 12 March 2024].

Tesla, n.d.. *Gigafactory Nevada.* [Online]
Available at: https://www.tesla.com/giga-nevada
[Accessed 26 March 2024].

The PerenniAl Group, n.d.. *About.* [Online]
Available at: https://www.theperennial-group.com/about
[Accessed 12 March 2024].

Tri-Arrow Aluminum, n.d.. *What we do.* [Online]
Available at: https://triaa.com/why-us/
[Accessed 10 April 2024].

UACJ, 2023. *UACJ Report 2023.* [Online]
Available at: https://www.uacj.co.jp/english/ir/library/pdf/2023/full_2023uacjr.pdf
[Accessed 13 March 2024].

UAJC, 2023. *Results Briefing for Fiscal 2022 (FY2022).* [Online]
Available at: https://ssl4.eir-parts.net/doc/5741/ir_material_for_fiscal_ym/135377/00.pdf
[Accessed 14 March 2024].

Ultimum Cells, 2021. *Ultium Cells LLC Announces Plans to Produce More Battery Cells Faster.* [Online]
Available at: https://www.ultiumcell.com/newsroom/News/2022/12/02/Ultium-Cells-LLC-Announces-Plans-to-Produce-More-Battery-Cells-Faster
[Accessed 26 March 2024].

Ultimum Cells, n.d.. *Lansing, Michigan.* [Online]
Available at: https://www.ultiumcell.com/our-locations/lansing-mi
[Accessed 26 March 2024].

Ultimum Cells, n.d.. *Warren, Ohiio.* [Online]
Available at: https://www.ultiumcell.com/our-locations/warren-oh
[Accessed 26 March 2024].

United States Department of Labor, 2023. *Quarterly Census of Employment and Wages.* [Online]
Available at:
https://data.bls.gov/cew/apps/table_maker/v4/table_maker.htm#type=0&year=2023&qtr=3&own=5&ind=3313&supp=0
[Accessed 3 April 2024].

van Weele, A. J., 2014. *Purchasing and Supply Chain Management.* 6th ed. Hampshire: Cengage Learning EMEA.

Van Weele, A. J., 2022. *Purchasing and Supply Chain Management.* 8th ed. Hampshire: Cengage Learning EMEA.

Vasconia Group, 2022. *Reporte Anual.* [Online]
Available at: https://www.grupovasconia.com/wp-content/uploads/ReporteAnual_2022_VASCONI_version-BIVA_Retrans.pdf
[Accessed 14 March 2024].

Vasconia Group, 2022. *Sustainability-Linked Bond Framework.* [Online]
Available at: https://www.grupovasconia.com/wp-content/uploads/IN_Framework-Vasconia_vf-5pm.pdf
[Accessed 14 March 2024].

Wang, M. J., 2022. *The Environmental Footprint of Semi-Fabricated Aluminum Products in North America,* s.l.: The Aluminum Association.

Watkins, D. C. & Gioia, D., 2015. Designing Mixed Methods Stuidies'. In: *Mixed Methods Reseach.* s.l.:Oxford University Press, pp. 17-44. doi: 10.1093/acprof:oso/9780199747450.003.0002.

Watson, C. D., 2022. *U.S. Aluminum Manufacturing: Industry Trends and Sustainability,* s.l.: Congressional Research Service.

World Business Council for Sustainable Development, 2004. *The Greenhouse Gas Protocol.* [Online]
Available at: https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf
[Accessed 21 March 2024].

Wozniak, J., 2022. *Kontrolmatik Technologies chooses Colleton County, South Carolina, for lithium-ion battery factory.* [Online]
Available at: https://www.us.jll.com/en/newsroom/kontrolmatik-technologies-chooses-colleton-county-south-carolina-for-lithium-ion-battery-factory
[Accessed 26 March 2024].

Yin, R., 2014. *Case study research.* 5 ed. s.l.:SAGE.

8 Appendix

8.4 Appendix A: Should-cost analysis process inspiration

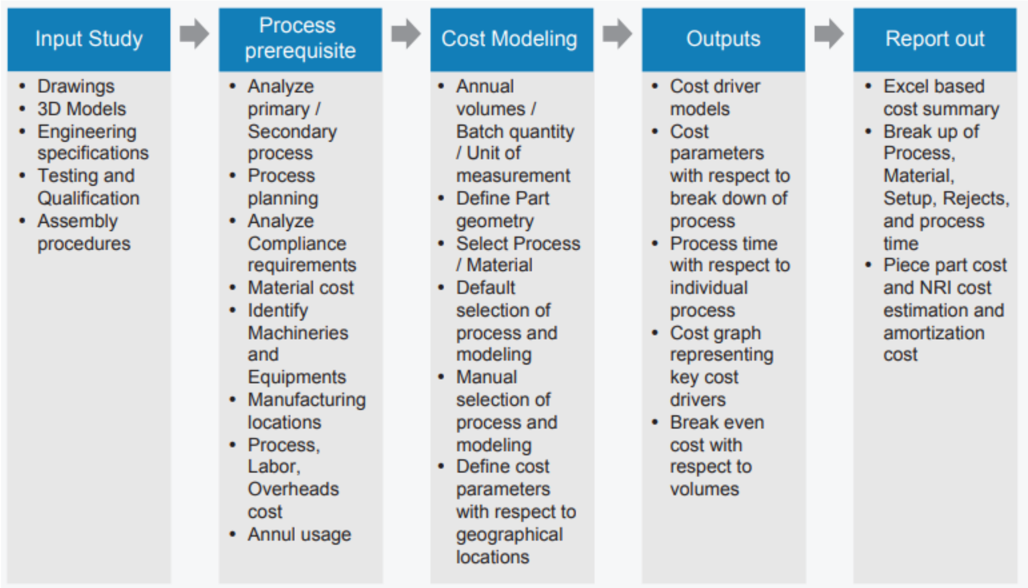

Figure 8.1: QuestGlobal's should-cost analysis process (2013)

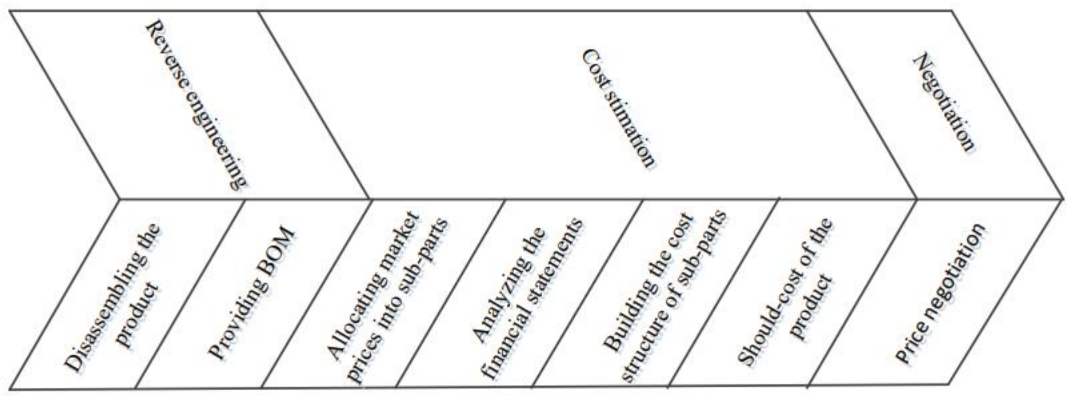

Figure 8.2: Mealer and Parks' Should-cost analysis process (2013). Illustrated by Parsa (2019)

8.5 Appendix B: Capacity analysis company descriptions

Table 8.1: Capacity analysis supplier descriptions

Company	Operation	Description
Rio Tinto	Bauxite, Alumina, Primary aluminum	Rio Tinto is a global mining group that focuses on finding, mining, and processing the Earth's mineral resources. Founded in 1873 and headquartered in London, UK, it is one of the world's largest metals and mining corporations, dealing primarily in aluminum, copper,

		diamonds, gold, industrial minerals (borates, titanium dioxide, and salt), iron ore, and uranium. (Rio Tinto, n.d.)
Atalco	Bauxite, Alumina	Atlantic Alumina specializes in producing smelter-grade alumina for aluminum manufacturing and chemical-grade alumina for various industrial applications. (Atalco, n.d.)
Alcoa	Bauxite, Alumina, Primary aluminum	Alcoa Corporation is a global industry leader in bauxite mining, alumina refining, and aluminum production. With a commitment to sustainability, Alcoa operates throughout the world, focusing on operational excellence and innovative technology to meet the global demand for aluminum. (Alcoa, n.d.)
Century Aluminum	Alumina, Primary aluminum	Century Aluminum Company is a global producer of primary aluminum, focusing on high-purity aluminum for the aerospace, automotive, and electrical industries. Headquartered in Chicago, Illinois, it operates primary aluminum smelters in the United States and Iceland. (Century Aluminum, n.d.)
The PerenniAl Group	Primary aluminum	The Perennial Group is a leading company in the global aluminum industry, specializing in distributing aluminum with a focus on sustainability and low-carbon initiatives. They cater to various industries by providing high-quality, environmentally focused aluminum products.
Constellium	Foil stock	Constellium is a global leader in the development and manufacturing of high-value aluminum products and solutions for a broad array of sectors, including aerospace, automotive, and packaging. Headquartered in Paris, France, the company is known for its innovation and expertise in aluminum processing and recycling. (Constellium, n.d.)
Novelis	Foil stock	Novelis Inc. is the world's largest recycler of aluminum, specializing in the production of aluminum rolled products for the automotive, beverage can, and specialties markets. With a focus on sustainability and innovation, Novelis operates in 10 countries and supplies premium aluminum sheet and foil products to customers worldwide. (Novelis, n.d.)

Arconic	Foil stock	Arconic Corporation specializes in lightweight metals engineering and manufacturing, focusing on producing aluminum sheets, plates, extrusions, and architectural products for aerospace, automotive, commercial transportation etc. Known for innovation and expertise in aluminum and advanced materials, Arconic operates globally, delivering high-performance solutions to a diverse client base. (Aronic, n.d.)
Tri-Arrow Aluminum	Foil stock	Tri-Arrows Aluminum Inc. focuses on producing rolled aluminum sheet primarily for the automotive industry, emphasizing lightweight, high-strength, and recycled aluminum solutions. They operate as a key supplier in North America, contributing to the development of more fuel-efficient vehicles through innovative aluminum products. (Tri-Arrow Aluminum, n.d.)
Almexa	Foil stock	Almexa Aluminio specializes in the manufacture and supply of rolled aluminum products, serving a variety of industries such as packaging, construction, and transportation in Mexico. With a focus on technology and quality, Almexa is committed to sustainability and innovation in the production of aluminum sheets, coils, and foils. (Almexa, n.d.)
Gränges	Foil stock, Thin foil	Gränges is a leading global supplier of advanced aluminum materials, focusing on rolled products for the heat exchanger, automotive, and HVAC industries. With a strong commitment to sustainability and innovation, Gränges specializes in the development and production of aluminum foil, strips, and sheets that enhance energy efficiency and reduce environmental impact. (Gränges, n.d.)
Lotte	Thin foil	Lotte Aluminum, part of the South Korean conglomerate Lotte Group, specializes in manufacturing a wide range of aluminum products, including packaging materials like aluminum foil and beverage cans, electronic components, and construction materials. Known for its innovation and quality, Lotte Aluminum is a leading aluminum manufacturer in Asia,

		committed to sustainability and technological advancement. (Lotte, n.d.)

8.6 Appendix C: EV battery companies and facilities capacity

Table 8.2: EV battery manufacturers factories' current and future demand

Company	Location	Demand (GWh)	Demand Foil (Tons)	SOP	Source
LG	Arizona	11	1540	2024	(Green Car Congress, 2022)
Ultium Cells	Tennessee	50	7000	2024	(Ultimum Cells, 2021)
Ultium Cells	Michigan	41	5740	2024	(Ultimum Cells, n.d.)
Freyr	Georgia	34	4760	2024	(Fischer, 2022)
SK Innovation (Blue Oval)	Tennessee	43	6020	2024	(Kane, 2021)
Kontrolmatik	South Carolina	3	420	2024	(Wozniak, 2022)
Honda & LG	Ohio	40	5600	2024	(Honda, 2023)
Stellantis & LG	Ontario	45	6300	2024	(Silveira & Morgan, 2022)
Tesla | Panasonic	Nevada	100	14000	2025	(Tesla, n.d.)
Amprius	Colorado	5	700	2025	(Amprius, 2023)
Kore Power	Arizona	12	1680	2025	(Kore Power, 2021)
American Battery Factory	Arizona	15	2100	2025	(American Battery Factory, n.d.)
Envision	Kentucky	40	5600	2025	(Kane, 2022)
Hyundai & SK	Georgia	35	4900	2025	(Johnson, 2023)
Hyundai & LG	Georgia	30	4200	2025	(Kane, 2023)
Stellantis & Samsung	Indiana	33	4620	2025	(Selveira & Morgan, 2023)
LG	Michigan	25	3500	2025	(LG, 2023)
Statevolt	California	54	7560	2025	(Statevolt, n.d.)
Ford	Tennessee	43	6020	2026	(Moloughney, 2023)
Ford	Michigan	35	4900	2026	(Ford, 2023)

Envision	South Carolina	30	4200	2026	(Kane, 2022)
SK Innovation (Blue Oval)	Kentucky	86	12040	2026	(Kane, 2021)
General Motors & Samsung	Indiana	30	4200	2026	(GM Authority, n.d.)
American Battery Solutions	Ohio	8	1120	2026	(American Battery Solutions, n.d.)
PowerCo	Ontario	90	12600	2027	(Dr. Ernst, 2023)
Gotion	Michigan	20	2800	2027	(Shepardson & Lienert, 2022)
Sakuu	California	60	8400	2028	(Sakuu, 2022)
Freyr & Koch	-	50	7000	2030	(Freyr Battery, 2021)
Stromvolt	Quebec	10	1400	2030	(Jarratt, 2021)
Tesla	Texas	100	14000	Online	(Lambert, 2022)
Panasonic	Kansas	30	4200	Online	(Panasonic, 2022)
Solid Power	Colorado	10	1400	Online	(Alamalhodaei, 2021)
Ultium Cells	Ohio	41	5740	Online	(Ultimum Cells, n.d.)
Envision	Tennessee	3	420	Online	(Kane, 2022)
SK Innovation	Georgia	21,5	3010	Online	(Kane, 2021)
Magnis	New York	1,8	252	Online	(Magnis, n.d.)
Lion Electric	Quebec	5	700	Online	(Lion Electric, 2023)
Our Next Energy	Michigan	20	2800	Online	(One, n.d.)
Electrovaya	New York	1	140	Online (2023)	(Electrovaya , 2022)
Rivian		50	7000		(Lienert, et al., 2021)
CATL	-	80	11200		(Kane, 2022)

8.7 Appendix D: Should-cost model variable parameters

Table 8.3: Should-cost model parameters

Aspect	Cost driver	Standard/ Average value	Source
Location	Country	USA/Canada/Mexico	
	State or Province	Relevant states	Capacity analysis
Capacity	Theoretical capacity (tons/year)	12 000*	Internal Northvolt proposal
	Desired foil width (mm)	1 650	Aluminum Foil Expert
	Working days (#)	330	Aluminum Foil Expert
	Scrap	20%	Aluminum Foil Expert
	Bottleneck process	Rolling	
	Bottleneck capacity (ignore if BN = Rolling)	-	
Material	Raw material foil stock ($/kg)	1,2	Aluminum Foil Expert
Equipment	Rolling mills in use	3	Internal Northvolt proposal
	Slitters in use	4	Internal Northvolt proposal
Operators	Operators Rolling	6	Aluminum Foil Expert
	Operators Slitting	3	Aluminum Foil Expert
	Operators Packaging	2	Aluminum Foil Expert
	Operators Maintenance	2	Aluminum Foil Expert
	Hours (h/shift)	8	Assumption that factory is operational day and night
	Shifts (h/day)	3	Assumption that factory is operational day and night
	Salary ($/h)	Varies depending on chosen country and state	(United States Department of Labor, 2023), (Jill, 2023)

Energy	Cost of energy ($/kWh)	Varies depending on chosen country and state	(Natural Resources Canada, 2023), (Electricity Local, n.d.)
	Energy usage (kWh/kg)	1,2	Aluminum Foil Expert
Depreciation	Foil rolling mills [$ each]	10 000*	Internal Northvolt proposal
	Sepaslitter machines ($)	20 000*	Internal Northvolt proposal
	Slitter machines ($)	35 000*	Internal Northvolt proposal
	Airpure systems foils ($)	12 000*	Internal Northvolt proposal
	Grinding machine ($)	17 000*	Internal Northvolt proposal
	Scrap handling and press ($)	14 000*	Internal Northvolt proposal
	Water and comp. air ($)	32 000*	Internal Northvolt proposal
	Crane storage system - flat ($)	22 000*	Internal Northvolt proposal
	Auxiliary equipment and scope completion ($)	41 000*	Internal Northvolt proposal
	Installation ($)	50% of equipment cost	Aluminum Foil Expert
	Investment Aid Equipment ($)	0	
	Value of buildings ($)	10 000 000*	Internal Northvolt proposal
	Investment Aid Buildings ($)	0	
	Value of land ($)	5 000 000*	Internal Northvolt proposal
	Investment Aid Land ($)	0	
	Depreciation equipment (years)	10	(Gränges, 2024)
	Depreciation building (years)	30	(Gränges, 2024)
	Depreciation land (years)	40	(Gränges, 2024)

Misc.	Cost of rolling oil per liter ($)	8,4	
	Rolling mill oil usage (liters)	80 000	Aluminum Foil Expert
Warehousing	Payment terms supplier (# days)	60	Cost analysis expert
	Payment terms buyer (# days)	30	Cost analysis expert
	Safety stock (# days)	10	Cost analysis expert
	Interest rate for stock (%)	5	Cost analysis expert
Transportation	Possible Box Returns (#)	5	Aluminum Foil Expert
	Cost of transportation ($)	[not part of production cost for supplier]	
	Core length (mm)	1 600	Hedsand, Max
	Core Value ($/m)	100	Hedsand, Max
	Packaging material cost per box ($/kg)	0,03	Hedsand, Max
	Core return ($/kg)	0,05	Internal Northvolt documents
	Possible core returns (#)	5	Hedsand, Max
	Packaging box return ($/kg)	0,05	Internal Northvolt documents
Finance	Total loan of equipment, buildings and land ($)	10 000 000*	Internal Northvolt documents
	Amortization (years)	10	
	Amortization years passed (years)	0	
	Interest rate for loan (%)	5	
SG&A	Overhead (%)	15%	Aluminum Foil Expert
LME	Premium ($/kg)	0,23	Hedsand, Max
	Price ($/kg)	2,67	Metal Stock Exchange
Profit	Profit margin (%)	10%	Aluminum Foil Expert

**Dummy number*

8.8 Appendix E: Interview guide

This section of the appendix presents the interview questions that were asked during the interviews that can be viewed in table 2.5. The interviews were structured and therefore all questions were asked to all interviewees, but there sometime some clarifying questions had to be asked. The questions are split into three sections: Procurement, supplier selection and negotiations, capacity analysis, and should-cost model. The questions can be viewed below.

Introduction

This interview is to enable us to answer our main research question, which is to analyze how a capacity analysis and a should-cost model can contribute to Northvolt's supplier selection and contracting process ahead of your new factory in Canada. The interview will begin by investigating Northvolt's overall strategy regarding procurement, supplier selection and negotiations. Afterwards, moving towards specific questions regarding how a capacity analysis and should-cost model can contribute to the processes respectively.

With your answers we can hopefully provide academic proof that these types of models are, in general, applicable several business situations, not just to Northvolt's.

Procurement, supplier selection, negotiations

- Northvolt's procurement strategy
    - In your opinion, does Northvolt's purchasing organization follow a typical structure, such as centralized, decentralized, hybrid or cross-functional?
    - What is your take on Northvolt's approach towards global vs local sourcing? What is the motive behind this decision?
    - Would you say that Northvolt has applied a category management approach regarding procurement? Please motivate.
        - If yes, how does the procurement strategies differ between direct categories and indirect categories?
- Supplier selection strategy
    - Is there a companywide policy for the supplier selection process? If not, is there one for your purchasing unit?
        - Do you aim for long-term relationships with suppliers, if so, what is the goal for this?
    - Could you summarize Northvolt's and/or your purchasing unit's strategy for supplier selection?
    - Do you have any personal additions regarding supplier selection strategy?
- Could you summarize Northvolt's and/or your purchasing unit's strategy for negotiations?
    - Do you have any personal additions regarding negotiations?

Capacity analysis

In our analysis we have included current and future capacity, GHG emissions and demand of battery cathode foil in North America

- Is this something you have been in contact with before, and if so:
    - In what situation?
    - Why was the analysis conducted?
    - Who conducted it?
    - How long did it take?
    - What was the information based on?
    - How was it conducted?
    - How did it help you in your situation?
- Is this an analysis you would use in the supplier selection process and ahead of negotiations?
    - If so, how did capacity analysis contribute to these situations?
- Would you say that this type of analysis is more applicable when selecting supplier in a new or existing market, or is it equally relevant to use when renegotiating with existing suppliers?
- Would you like to see different data points that can improve the analysis quality?
- Is there anything you would like to add? Again, we are looking for insights regarding how this type of analysis can contribute to your work regarding supplier selection and negotiations with suppliers.

Should-cost model

Our model breaks down key cost-factors to evaluate the 'should-cost' to produce battery cathode foil

- Strategic cost management
    - Something you are familiar with?
    - Something you work with now?
    - Something you want to work with?
- Have you been in contact with should-cost modelling before or any other strategic cost management tool such as Total Cost of Ownership, Activity based costing, Cost-ratio, Life cycle costing etc.?
    - If you have, which one did you use and why?
- Would you say that the purchasing structure is relevant when conducting these types of analytics?
- Do you think a should-cost model could be applied to improve contracting terms?
- Would you apply to your commodity, why/why not?
- Which situations do you deem relevant for this sort of analysis?
- In your opinion, how do you think should-costing can contribute to supplier selection and supplier negotiations?

8.9 Appendix F: Interview summaries

8.9.1 Organizational procurement strategies answers summary

Table 8.4: Summary of answers regarding procurement strategies, supplier selection and negotiations

Topic	Director purchasing	Category manager 1	Category manager 2	Category manager 3	Category manager 4
Procurement	No different strategies applied between indirect and direct materials	Aiming to make it more standardized	Big focus at NV.	Every category has its own unique challenge which makes it difficult to apply organizational guidelines for procurement. However, there are clearcut ambitions and strategies for procurement, but to which level these are possible to follow varies.	We primarily purchase complex products in large volumes, making category management a more suitable strategy for us than project-based purchasing. It's crucial for our category managers to have a deep understanding of their respective categories, including market conditions, suppliers, and regional variations.
Structure	Centralized but moving towards decentralized and cross-functional	Centralized as we are working in a very systematic way	There is a global purchasing process that has to be followed.	Clear incentives and directives from above, however, each category manager is free to apply suitable strategies as they see fit (hybrid)	Hybrid. Central organization in Stockholm with operative units at every factory. Bigger questions are sent to category managers.
Category Management	Yes, no other strategy is applicable	Yes, not aware of any other	It is common practice.		Communication is also an important

		relevant philosophies. It is efficient and effective.	The company has a large supply chain focus. Easier for people to know who owns what.		factor for choosing local sourcing. Easier to travel to Italy to meet a supplier than Korea.
Local / global sourcing	Local, to meet environmental ambitions and cut down lead-times of sensitive materials	Local, to reduce risk. Challenging and more expensive to pursue a local supply chain.	Local, the global supply chain wasn't that strong when COVID and the war came. Things that are specifically produced for NV (OEMs?) are nice to have close. Factors such as size, criticalness, corruption in supplier country, difficulty to ship etc. are important to handle.	The manager's category is influenced by the short shelf-life, which makes local suppliers appropriate to reduce supply chain risk. Apart from hedging risk, the environmental aspects of local sourcing are also of consideration.	
Supplier Selection	Matching philosophies, long-lasting relations since the operations have incorporated the specific	Standardized process. Aim for long-term relations. Depending on the relevancy of the supplier	There is a distinct supplier selection process. There are important criteria. Use	Aims for long-term collaboration and co-develop suitable solutions for supply as the	There is a standard policy. Iteratively improving, e.g. better due diligence. Documents are

	supply materials	the organizational interference varies. Involves screening and systematic evaluation. Important to align the entire supply chain: as Northvolt pursues long-term relations with their customers, which expect a certain level of quantity and quality, it is logical that NV expect the same from their suppliers.	of TCO, LCA to evaluate. Also, NV wants to work with suppliers that want to work with NV, wants to help build NV, has patience, help in the good and bad stages. Very hard to change suppliers. Several business units have to be involved. The supplier is also evaluated based on how well they can harmonize with the category management system. Quarterly business reviews.	material is niche and tailored to fit into the production of Northvolt batteries. In this category the available suppliers are quite low, which makes multiple sourcing difficult. The lead-time from initial contact to actually receiving supply could take up to 1,5 years.	filled which puts a supplier in a risk category. A council judges the supplier afterwards. This is done for new suppliers. For existing we have a scorecard, and evaluations are done annually. Audits are conducted as well. All of this is easier for local suppliers.
Negotiations	Up to the category manager (decentralized)	Not an established structure and/or	-	-	No policy regarding negotiations. You want to

	, analyzing the supply situation and applying fitting strategies	strategy for how to conduct negotiations			achieve the goals: price, environment, payment terms, warranty, liability, shelf-life etc. Price and co2 are two easily measurable goals.
Other input	-	-	-	The managers' material relevant for procurement is quite complex when compared to foils. It is R&D intensive, short shelf-life, difficult to produce	-

8.9.2 Capacity analysis interview answers summary

Table 8.5: Answers from interview questions regarding capacity analysis

Capacity Topic	Director purchasing	Category manager 1	Category manager 2	Category manager 3	Category manager 4
Familiarity	Something they have actively worked with	Not familiar with this type of capacity analysis	Conducts capacity analysis a different way. "Does the supplier have enough to satisfy our needs?".	Familiar but not relevant for this category, as of now.	Conducted this type of analysis for different market, but not the same detail as for this thesis
Process and structure	Depends on the commodity and the	The relevancy of the capacity analysis is	A part of the category work is to map what type of	Normally the category managers are responsible	Information comes from Google, company

	external factors. Iterative process (news and supply updates). The category managers are deciding if it is applicable	heavily dictated by the maturity of the market. Relevant to understand the competition in the market	suppliers in this category depending on geographic location, competence.	for this type of analysis	reports, events, internal documents.
Beneficial to supplier selection and contracting	Understand supply risks and market situation	Gives a good foundation for securing supply	Yes, there is value to conduct this type of analysis. It might be about volumes, how much is there, how much do we need etc. Program specific products is something that could benefit from this.	Not beneficial to this category, as there is no guarantee that they can deliver the appropriate supply to Northvolt even if there is capacity. But in the future, there might be a relevancy as the market is quickly developing	Yes, there is a lot of value in confirming a hypothesis of how a market looks like. For example, for North America, we confirmed what we though regarding supplier and capacity situation
Other input	Look into regulations and legal requirements	Might give a false perception about the future of the market, where demand is significantly less than projected. What matter outside of	Also, the volumes the manager and her team purchases are not of the same size as the directors, so this kind of analysis is not that relevant for them. They already know that there is a	-	Important to keep the analysis updated. In six months, it will be pretty much worthless. The usefulness of the model depends on if there are

		the actual capacity is how much they are willing to dedicate towards Northvolt	lot of capacity for e.g. contacts. Their unit purchases much more specific and complex products. There are not going to be a lot of suppliers that, off the shelf, can provide that kind of product. That is why this kind of analysis is not that relevant. However, supply risk products, such as semiconductors, is nice to analyze to see weaknesses in that supply chain. The market the manager works in, there are a lot of global suppliers. They are already aware of which ones there are.		suppliers, how specific is the purchased product, is there data available.

8.9.3 Should-cost model interview answers summary

Table 8.6: Summary of answers regarding the should-cost model

Should-cost Topic	Director purchasing	Category manager 1	Category manager 2	Category manager 3	Category manager 4

Familiarity	Familiar with the concept and process	Familiar with this type of model and theory	Yes, familiar with the model. It is very good and nice.	Familiar with the concept of breaking down products into its most fundamental cost-drivers.	Familiar with the model. But not in the detail we have conducted
Strategic Cost Management	No pressure from top level to implement or integrate. Up to the team or category manager to ensure goals are accomplished		Yes, we work with this daily. Being pushed internally.	Trying to reach certain goals for costs, even though most are self-constructed. Most are revolving around process- and material costs	Recognize the term, not the definition. A common thing to work with now is to break down cost drivers and activities. NV must work with a bottom-up approach to cost with suppliers. Wants to work top-down in the future when they are more familiar with what products should cost
Relevance and goals	High relevance, applicable tool to assist in meeting the organizational goals and ambitions	High relevancy, crucial to understanding the underlying cost-structures.	Applicable for her category. A very good model to apply. Work with the tool, don't just create it and leave it alone.	Having a model which can iteratively be improved is always beneficial to reach cost-reductions and foster understandin	Highly relevant analysis for all categories but is going to be more challenging for more specifically designed and

	regarding costs		Iteratively work with it.	g of the underlying costs	complex products.
Supplier relations	Important to understand underlying costs in order to challenge and/or cooperate with long-term suppliers	Supplier evaluation is important, have previously done AHP-analysis for this.		Can be used to communicate strategies with suppliers, both in terms of receiving relevant data but also to potentially reduce prices. The data received could then be applied in negotiation with other suppliers to iteratively increase accuracy and leverage potential	Helps to understand cost differences between suppliers, set benchmarks, understand if suppliers are bluffing, understand margins, challenge suppliers
Other input	Up to each category manager to decide if it aligns with their strategy	When comparing the Korean and Chinese suppliers it became evident that the amount of depreciation years had a clear impact on the price. It does not matter how much you	They have cost engineers that work with this. One important note, the one creating the model is also creating a cost target for that product. So, depending on if the	The manager wants to implement this type of strategy/modelling, but the complexity of the category makes it difficult to apply.	The model can help managers understand how production capacity can increase costs for suppliers. Data is going to be vital for the model to function correctly.

		understand regarding the cost-structures if the supplier is not willing to cooperate regarding information and reducing costs.	manager or the cost engineer is creating the model and cost target, the goal of reaching that cost target might be easier or harder. That is why it is important to work close together with your cost engineer, if you have one.		