Powering Tomorrow - Implementation of Battery Energy Storage System in today's Power Grid

Henrik Ramström, Krenar Gerxhaliu

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Supervisor: Ingela Elofsson
University lecturer at Production Economics
E-post: ingela.elofsson@iml.lth.se
Telefon: +46 46 222 80 08

Examiner: Ola Alexanderson
Lector
E-post: ola.alexanderson@iml.lth.se
Tel: +46 462228009

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Handledare: Ingela Elofsson
Universitetsadjunkt vid Produktionsekonomi
E-post: ingela.elofsson@iml.lth.se
Telefon: +46 46 222 80 08

Examinator: Ola Alexanderson
Universitetslektor
ola.alexanderson@iml.lth.se
Tel: +46462228009

Abstract

Title

Powering Tomorrow - Implementation of Battery Energy Storage System in today's Power Grid

Authors

Henrik Ramström and Krenar Gerxhaliu

Supervisor

Ingela Elofsson, Dept. of Production Management, Faculty of Engineering, Lund University

Maricruz Bravo, Flower Infrastructure Technologies AB

Background

We are currently undergoing a transition in the industrial development, taking place globally. Significant economic growth and technological advancements have occurred, but this has also resulted in environmental problems due to the extensive use of fossil fuels. Consequently, there is a need for a shift towards more sustainable energy sources such as solar, wind, and water. This transaction naturally comes with challenges. These unplannable energy sources require support systems to be used effectively. While support systems are already in use to some extent, the industry lacks sufficient research. This work aims to provide a more comprehensive description and analysis of the relevant considerations concerning technology acquisition in this industry and the consequences these considerations will have.

Purpose

The purpose of this study is to describe the development of high-tech services in the energy sector in Sweden by analysing the consequences of technology acquisition and knowledge basis in companies.

Methodology

In order to do this a framework has been proposed where a current analysis of the company is created. From this, 6 scenarios of the future were proposed with the help of technology strategy in order to evaluate different implementations of the developed product.

Delimitations

This study focuses on the acquisition of a service stacking product in a high-tech service sector, this being the Swedish energy sector. Specifically, services related to grid balancing where this thesis applies a theoretical framework to a specific case study involving Flower Infrastructure Technologies AB.

Conclusions

Based on the empiricism found, the theoretical framework used and the analysis conducted several conclusions have been made. The development of the product in this case would entail only a small amount of value. In comparison, several added capabilities need to be implemented to drive this change.

Keywords

Battery energy storage system, Technology strategy, Resource based view, Technology acquisition, Technology life cycle, Virtual power plant, Value proposition, Ancillary services, Energy market, Innovation, Product development

Sammanfattning

Titel

Powering Tomorrow - Implementation of Battery Energy Storage System in today's Power Grid

Författare

Henrik Ramström och Krenar Gerxhaliu

Handledare

Ingela Elofsson, Avdelningen för produktionsekonomi vid Lunds tekniska högskola

Maricruz Bravo, Flower Infrastructure Technologies AB

Bakgrund

Vi genomgår idag en stor omställning som samhälle. Detta sker till stor del på grund av elektrifieringen i samhället som medför såväl en betydande ekonomisk som teknologisk påverkan. Som följd av detta har det skett en stor övergång till mer hållbara energikällor inom elkraft marknaden. Dessa energikällor är däremot inte alltid så lätta att implementera. Som exempel kräver oplanerbara energikällor stödsystem för att kunna användas effektivt. Dessa stödsystem används redan idag till en viss utsträckning men användandet den fortsatta utvecklingen sätter idag nya utmaningar. Implementering av effektiv teknologianförskaffning inom branschen kommer därmed bli avgörande. Detta arbete hoppas därför ge en mer utförlig beskrivning och analys av vilka överväganden som är intressanta vid teknologianförskaffning i branschen och vilka konsekvenser dessa övervägningar kommer få för företagen som väljer olika metoder att införskaffa dessa.

Syfte

Syftet med detta arbete är att beskriva och analysera utvecklingen av högteknologiska tjänster och dess konsekvenser för teknologianskaffning och kunskapsbaser på ett företag som agerar inom energisektorn i Sverige.

Metodologi

För att uppnå syftet har ett ramverk föreslagits där en aktuell analys av företaget skapas. Utifrån detta föreslogs 6 scenarier för framtiden med hjälp av teknologistrategi för att utvärdera olika implementeringar av det utvecklade produkten.

Avgränsningar

Denna studie fokuserar på utvecklingen av högteknologiska tjänster inom den svenska energisektorn, särskilt tjänster relaterade till balansering av elnätet där den tillämpar ett teoretiskt ramverk på ett specifikt fallstudie företag, Flower Infrastructure Technologies AB. Eftersom företaget verkar i Sverige kommer rapporten främst att fokusera på den svenska elkraft marknaden.

Slutsatser

Baserat på den empiri som hittats, det använda teoretiska ramverket och genomförda analyser har flera slutsatser dragits. Utvecklingen av produkten i detta fall skulle endast medföra en liten mängd värde. I jämförelse skulle flera stora tilläggskapaciteter behöva implementeras för att driva denna förändring.

Nyckelord

Batterilagringssystem, Teknologistrategi, Resurser och kompetenser,

Teknologianskaffning, Teknologins livscykel, Virtuellt kraftverk, Värdeerbjudande,

Hjälptjänster, Energimarknad, Innovation, Produktutveckling.

Acknowledgments

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We are grateful to Flower Infrastructure Technology AB for providing us with the opportunity to conduct this research through their company and helping us aspiring master's students to explore the challenge of technology acquisition at a high-tech company. We would especially like to thank our supervisor at Flower Infrastructure Technology AB, Maricruz Bravo. In addition to assisting us in setting up interviews with other employees at Flower Infrastructure Technology AB, Maricruz has been a true inspiration with her knowledge, experience and always positive attitude. It has truly been a pleasure working alongside you!

Alongside Maricruz, we would also like to give a thank you to Mikael Bergmark at Flower Infrastructure Technology AB who acted as our first contact person. Without you we would not have come in contact with Maricruz and we therefore thank you for this opportunity you gave us!

We would also like to thank our academic supervisor, Ingela Elofsson, for her valuable guidance and support throughout the process of writing this thesis. Her expertise and insights have been valuable for structuring the research and keeping a steady course, without her this would not have been possible!

We would also like to extend our gratitude to the interviewees, both internally at Flower Infrastructure Technology AB and externally, for their time, knowledge, and opinions. Their input has made this thesis possible!

Finally, we would like to give a thank you to our loved ones that have assisted us in this thesis. Both family, partners and friends have helped with proofreading, inspiration and support for this thesis, without your help while writing this thesis it would not have turned out anything like this. Thank you!

Lund, February 2024

Henrik Ramström

Krenar Gerxhaliu

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List of Acronyms and Abbreviations

aFRR - Automatic frequency Restoration Reserve

BCU - Battery Control Unit

BoL - Beginning of Life.

CAN - Controller Area Network

CMU - Central Monitoring Unit

CSC - Cell Supervision Circuit

CSU - Current Sensor Unit

BESS - Battery energy storage system

BMS - Battery management system

BMU - Battery Monitoring Unit

EMS Energy Management System

ETH - Ethernet

EoL - End of Life.

ESS - Energy storage system

EV - Electric vehicle

FCR-D - Upward/Downward Frequency Containment

FCR-N - Frequency containment Reserve

FFR - Fast Frequency Reserve

Flower - Flower Infrastructure Technologies AB

ICT - Information & Communication Technologies

LIB - Lithium ion batteries

M&A - Merger and acquisition

MBMU - Main Battery Management Unit

MBUS - Monitoring bus

mFRR - Manual Frequency Restoration Reserve

ML - Machine learning

SoC - State of charge

SoH - State of health

PCS - Power Conversion System

PCoS - Power control systems

PID - Potential Induced Degradation

PLC - Power Line Communication

POI - Point of Interconnection

RBV - Resource based view

RTE - Round Trip Efficiency

SBMU - System Battery Management Unit

TSO - Transmission system Operator

VPP - Virtual power plant

Table of content

1. Introduction

This chapter presents the relevant topics and background necessary to understand why this thesis is made. It also presents the purpose of the thesis and the delimitations that were made in the creation of the thesis.

1.1 Background

The Industrial Revolution marked a transformative era, propelling societies into unprecedented economic growth and technological advancements. However, this surge in progress came at a cost, as the widespread adoption of fossil fuels became a cornerstone of the global demand for energy (Landes, 1969; Allen, 2009; IEA, 2023a; Saidi & Hammami, 2015). The fuel's ability to meet the energy needs of a growing population and economy, without raising prices, has been central to improving human well-being since the Industrial Revolution. However, these fuels have also been spewing out carbon dioxide, driving global warming (Allen, 2009; IEA, 2023a). Consequently, the continuous rise in energy consumption alongside these environmental challenges necessitates a reevaluation of our energy system (IEA, 2023a). Today, in response to these challenges, there is a green transition underway, intensifying due to key drivers such as environmental policies and a growing environmentally aware consumer base (EU, n.d.; Energimyndigheten, 2023a; Kotler, Armstrong & Parment, 2016; IEA, n.d.a). All of this emphasises the urgency of transitioning to more sustainable energy bearers like solar, wind and hydro (IEA, n.d.b). These energy providers however come with their own unique set of challenges, particularly in the stabilisation and resilience of electric power grid systems (Smith, et. al., 2022). The renewable energy sources face challenges such as uncertainty in power generation, rising grid loads, and fundamental changes in dynamic properties which in due turn necessitate the implementation of ancillary services in the power grid (Kruse, Schäfer, & Witthaut, Ny Teknik, 2023; 2021; Smith, et. al., 2022; Vattenfall, n.d).

In order to meet this demand, technology acquisition has to be considered a fundamental aspect. This is due to the fact that the choice of developing your own product or service and your technology strategies will greatly determine if the company can transition to positions of global implementation (Davenport, Campbell-Hunt & Solomon, 2003). The reason is that the choices made for technology strategies significantly influence every facet of a company's development, from cost structures to corporate culture and marketing strategies (Davenport, Campbell-Hunt & Solomon, 2003; Kotler, Armstrong & Parment, 2016)). Consequently, a rigorous and comprehensive analysis is imperative before making this strategic choice to determine the most suitable path forward. This dedication to making informed decisions when outsourcing was a central theme in Oliver E. Williamson's Nobel Prize awarded in 2009 (Nobel Prize, 2009; Logistics viewpoint, 2010; Vested, 2010).

One of these decisions is whether to develop a technology in-house or procure it externally where, for example, one problem that might occur is whether this is in line with the company's technology strategies. This deliberation extends to discerning potential opportunities and consequently identifying uncharted markets where the company might be able to go. In other words, it marks an extension of the realm of the company's capabilities (Ford & Thomas, 1997). It therefore places particular emphasis on the strategies related to technology acquisition (Ford & Thomas, 1997). To create this a comprehensive investigation of various methods and acquiring the technology is vital, spanning in-house development, research and development (R&D), licensing, contractual arrangements, and joint ventures. In making this decision, a forward-thinking approach becomes paramount, integrating the case company's long-term strategies into the decision-making process (Ford, 1988; Davenport, Campbell-Hunt & Solomon, 2003; Prahalad & Hamel, 1990). This approach ensures alignment between the current decision and the company's future strategies, fostering a coherent strategy that permeates the entire organisation, leading to competitive advantages (Ford, 1988; Prahalad & Hamel, 1990). Furthermore, this evaluation must closely harmonise with the company's competencies as the aligning business strategies should be viewed through the prism of the company's existing strengths and the value it can deliver through these acquisitions (Ford, 1988; Davenport, Campbell-Hunt & Solomon, 2003; Prahalad & Hamel, 1990).

As has been shown above there is great interest in the subject matters discussed, but still, the strategic decision is often not taken seriously enough. Therefore, many companies have problems with the use of strategic methods and forecasting the consequences of the implemented strategies they use. (Papulova & Gazova, 2016). The knowledge gap is therefore clear and this signifies a need for further explorations of the ramifications of strategic choices The theory of in-/versus outsourcing was traditionally centred solely on the advantages of self-sufficiency. It was widely believed that expanding vertical integration across the value chain would grant greater control and enhance a company's self-reliance, making insourcing the definite preference over outsourcing (NI Business, 2023; Edgren & Skärvad, 2010; Bryce & Useem, 1998). However, recent decades have witnessed a notable shift in this paradigm. Newer research has also focused on the contributions of outsourcing in reducing costs and enhancing flexibility. This has sparked a growing trend towards company specialisation, where companies concentrate more on their core values and what they can provide for the end user (Bryce & Useem, 1998; Edgren & Skärvad 2010). This decision to internally develop and manufacture is a critical strategic choice that every company must navigate at some point in its journey to maintain competitiveness (Johnson, Whittington & Scholes, 2012; Papulova & Gazova, 2016). These choices also change when the market's decisions change and the choices are therefore always in need of revaluation (Papulova & Gazova, 2016).

1.2 Purpose

The purpose of this study is to describe the development of high-tech services in the energy sector in Sweden, by analysing the consequences of technology acquisition and knowledge basis in companies.

1.3 Delimitations

This study focuses on high-tech service development within the Swedish energy sector, specifically services related to grid balancing, and applies theoretical models to a specific case study involving the case study company, Flower Infrastructure Technologies AB. Flower Infrastructure Technologies AB operates at the intersection of high-tech service development and grid balancing. The company's role in managing the challenges associated with decision-making in the development of high-tech services and its unique position in the market makes it a compelling subject of investigation.

As the company operates in Sweden mainly the report will primarily focus on the Swedish market. An interesting technology that's now being implemented in this market is the usage of Battery energy storage system (BESS) technology. Therefore this work will primarily deal with the acquisition of this technology into the case company.

When dealing with the acquisition of technology there are two types of technology procurement that one might evaluate as either a product technology or production technology. As this work primarily deals with a product, the BESS, this thesis will focus on product technology.

A strategic alliance can take multiple forms. In this thesis, the use case of a joint venture will be used to showcase a way of working in a strategic alliance. The reasoning behind this is that the strategic alliance can take multiple forms and as most of the information was gathered from Jay B Barney's work will be used as it's his favourite showcase of a strategic alliance.

As the ancillary services market is currently the most under-researched market it has been selected as the one researched in this thesis. This however comes with a constraint as only Li-Ion batteries are currently able to handle the fast response times required while also having a high enough energy density to be profitable. Some other batteries will also be discussed but only to give ample situational knowledge to understand how they are affecting the Swedish energy market today.

1.4 Structure of the Report

Table 1 - Table of the chapters and their content

Chapter	Purpose of Chapter
1	This chapter presents the relevant topics and background necessary to understand why this thesis is made. It also presents the purpose of the thesis and the delimitations that were made in the creation of the thesis.
2	This chapter presents the research purpose and strategy of this thesis. Especially the approach for conducting descriptive and investigative research on the development of high-tech services in the energy sector in Sweden. It also gives an overview of the design of the different segments conducted to get to the conclusion, as well as an introduction to the scenario planning that was conducted in the thesis.
3	This chapter presents the relevant theories and models that were needed to create the framework used in this thesis. It contains an overview of the 5 major theories used and the sub-theories that were also integrated into the framework to complete the purpose of this thesis.
4	This chapter contains a pre-study of the studied company Flower Infrastructure Technologies AB, the market that they operate in, as well as, the development of BESS technologies. All aspects which are needed in order to understand the empiricism and analysis for the following chapters will be displayed.
5	This chapter provides the theoretical model, empiricism and analysis of the company today. From which it provides a current analysis of Flower Infrastructure Technologies AB in which it describes how the company is operating today.
6	This chapter presents the six scenarios which were used in this thesis to understand the future. From these scenarios, it uses the theoretical models, empiricism and analysis of the future to conclude what type of differences each scenario would entail.
7	This chapter presents what changes each scenario would entail and provides an overview of how great of a difference each identified change would make. An analysis of these is also conducted and presented.
8	This chapter showcases and presents the conclusions that can be made from the empiricism and analysis made in earlier chapters.
9	This chapter contains a discussion of the limitations of the thesis created. It also provides a discussion about the future improvements of the methodology, as well as, what future work was deemed to be of interest from this thesis.

2. Methodology

This chapter presents the research purpose and strategy of this thesis. Especially the approach for conducting descriptive and investigative research on the development of high-tech services in the energy sector in Sweden. It also gives an overview of the design of the different segments conducted to get to the conclusion, as well as an introduction to the scenario planning that was conducted in the thesis.

2.1 Research Purpose

When conducting scientific research, the purpose of the study is to provide guidelines and steer the investigation in the intended direction. For a given subject, different purposes can be employed, and therefore, it's important to categorise studies to better understand what they encompass – and what they exclude. Scientific research can be categorised into four main types of purposes: descriptive, exploratory, explanatory, and problem-solving (Blomkvist & Hallin, 2014).

A descriptive study is conducted to provide a fundamental account, aiming to elucidate a specific phenomenon or event. On the other hand, an exploratory study aims to delve deeper and comprehensively investigate a phenomenon or event. An explanatory study represents a variant in which the objective is to comprehend the correlations and fundamental reasons behind a phenomenon or event (Blomkvist & Hallin, 2014). A problem-solving study differs somewhat, primarily focusing on seeking solutions to identified problems.

Based on this information and the purpose of this study (see 1.2), a descriptive and exploratory study is suitable for this research. To begin with, a descriptive study aligns with the main objective of analysing the development of high-tech services within the energy sector in Sweden. By exploring various aspects and carefully considering the unique context of this industry, insgightufl descriptions and analyses can be performed which effectively address the identified objective, contributing to a comprehensive understanding of the evolution of high-tech services in the Swedish energy sector. Additionally, an exploratory study is well-suited for this research as it aims to delve deeply into the development of high-tech services within the energy sector in Sweden. By thoroughly examining the existing landscape and potential trends, we aim to gain key insights to better understand the complexities involved in this critical sector.

2.2 Research Strategy

The objective of this thesis is, as earlier stated, (see part 1.2) to "*describe and analyse the development of high-tech services and the consequences for the technology acquisition and knowledge basis*". In order to do this the thesis will have to state where a service is today, where it will be tomorrow and evaluate what changes have occurred. This thesis will therefore consist of different sections, the first being a current-day analysis. Based on what the theory say needs to be procured, this part will provide empiricism, based on theory, to understand the acquisition of knowledge and knowledge basis in the case company today. After this, the frameworks will be applied in the same order as they were introduced in the Chapters to interpret and conclude the current-day analysis. After this scenario planning will be used to predict which future scenarios might be of interest to analyse. With these scenarios decided, they will all be interpreted and re-analysed by the same theory as in the current-day analysis in order to say what the future of the company will look like. In this future analysis, certain gaps will present themselves from which results will be deduced about what changes will occur in the development of high-tech services.

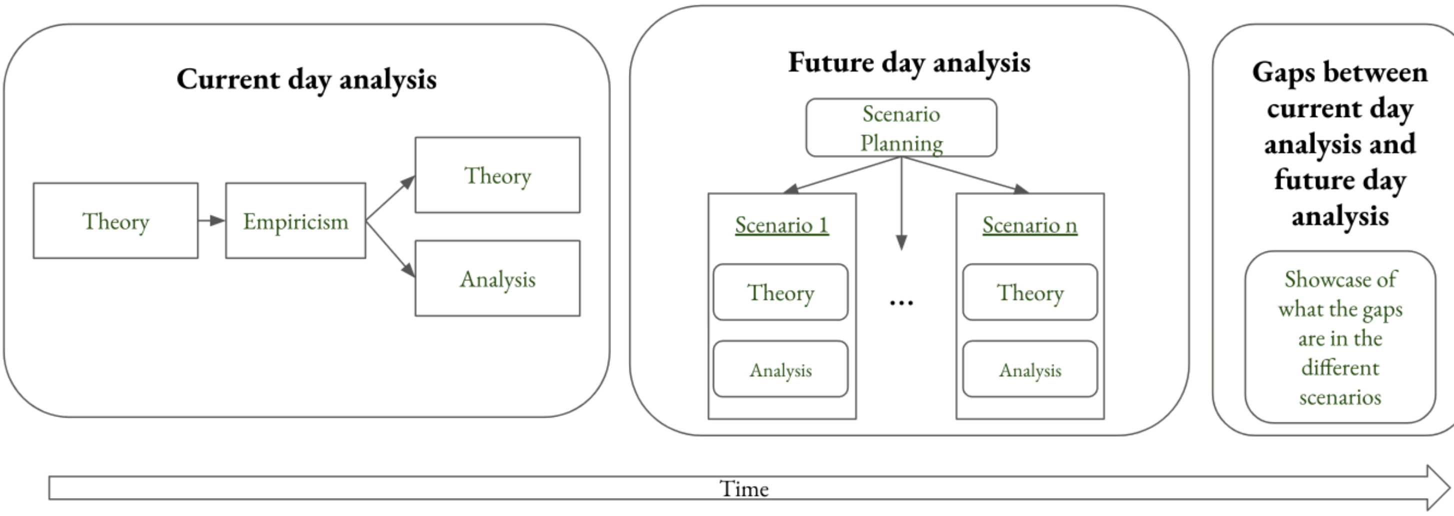

Figure 1 - Illustration of the research strategy

2.2.1 Deductive, Inductive and Abductive Research

The fundamental process of answering research questions involves the use of theory. The degree to which addressing research questions encompasses either theory testing or theory development poses a crucial concern regarding the planning and design of research. This is frequently framed as a distinction between deductive and inductive reasoning, but there is also an abductive approach, see Table 2 below (Saunders et al., 2007).

Table 2 - Table of how deductive, inductive and abductive research is connected to logic, generalisability, use of data and theory

	Deduction	**Induction**	**Abduction**
Logic	In a deductive interference, when the premises are true, the conclusion must also be true.	In an inductive interference, known premises are used to generate untested conclusions.	In an abductive inference, known premises are used to generate testable conclusions.
Generalisability	Generalising from the general to the specific	Generalising from the specific to the general.	Generalising from the interactions between the specific and the general.
Use of data	Data collection is used to evaluate propositions or hypotheses related to an existing theory.	Data collection is used to explore a phenomenon, identify themes and patterns and create a conceptual framework.	Data collection is used to explore a phenomenon, identify themes and patterns, locate these in a conceptual framework and test this through subsequent data collection and so forth.
Theory	Theory falsification or verification.	Theory generation and building	Theory generation or modification; incorporating existing theory where appropriate, to build new theory or modify existing theory.

Unlike the linear progression from theory to data (deduction) or from data to theory (induction), an abductive approach involves dynamic feedback between data and theory, where comparisons and interpretations occur, effectively merging elements of both deduction and induction (Suddaby, 2006).

Why is this important? According to Easterby-Smith et al. (2012), there are three reasons: Firstly, understanding research traditions aids in making informed decisions about research design, encompassing the collection of evidence, its sources and interpretation. Secondly, it facilitates the selection of research strategies that align with specific research goals. At last, knowledge of research traditions allows for adaptable research design, accommodating practical constraints and limitations in prior subject knowledge.

Given the purpose of this paper, an abductive approach is suitable. Due to, the purpose of this study being to describe and analyse the development of high-tech services and the consequences for the technology acquisition and knowledge basis in a company within the energy sector in Sweden. This involves a balance between existing theory and knowledge, and the need to propose a new framework. Additionally, abduction is suitable when theory is to be further developed in investigations built around case studies, which is also the research method of this work.

2.2.2. Qualitative Versus Quantitative Approach

Data collection in research involves two main categories: quantitative and qualitative. Quantitative data is easily quantifiable and lends itself to statistical analysis, often collected mechanically. In contrast, qualitative data, consisting of descriptions and interpretations, is challenging to automate due to its nuanced nature. Some examples of qualitative data are interviews, observations and textual analysis. Utilising both data types enables comprehensive knowledge acquisition (Tracy, 2020).

Qualitative data is well-suited for this thesis, facilitating the exploration of nuanced factors and providing in-depth insights into Flower Infrastructure Technologies AB's complex decision-making processes. This approach aligns with the study's focus on comprehensively analysing and interpreting the factors influencing Flower Technologies' strategic decisions. Therefore, conducting one-on-one interviews with individuals who meet our criteria will significantly contribute to understanding this complex subject.

2.2.3 Validity and Reliability

Validity in research is about the relevance of the data gathered for the objectives of the research and how well the gathered data is a correct representation of the phenomena studied. To ensure validity, measures must be taken both in the data-gathering process and in the processing of the data. (Mälardalens universitet, 2022b)

For this thesis, measures for validity for interviews include carefully structured interview guides, with both open questions that are not leading the interviewee on, but also closed follow-up questions that allow for exact information when needed.

Regarding the relevance of theory, models, and other empirical material several sources were used to define important areas, and by iteratively evaluating the gathered data.

For quantitative studies, reliability is about choosing a method that will give similar results if the study is repeated. However, for qualitative studies, like this one, reliability cannot be ensured using numerical methods. (Mälardalens universitet, 2022a) Instead, this thesis addressed reliability by clearly explaining how data has been gathered and analysed.

2.3 Research Design

2.3.1 Case Studies

There are three common types of research designs: *case study*, *quantitative study*, and *experimental and action research* (Blomkvist and Hallin, 2014). A case study is utilised in this master's thesis for its effectiveness in conducting an in-depth exploration of real-world phenomena. This approach enables the examination of complex and context-specific issues, which aligns with the research's focus. By delving into the intricacies of the chosen case, a comprehensive understanding of the subject matter is gained, leading to valuable insights. Ultimately, the findings from this case study will serve as the foundation for developing recommendations to guide Flower Infrastructure Technologies AB in making informed decisions about its future course of action.

2.3.1.1 Selection

In order to follow the recommendations set by Blomkvist and Halling (2014), industry experts, particularly those with a profound understanding of BESS technology, will be interviewed. For this purpose, a case company was decided in Flower Infrastructure Technologies AB. Flower Infrastructure Technologies AB has currently a majority stake in the ancillary service market for power grids in Sweden and is also exploring new technology acquisitions. Thus making it a well-situated case company for this study. Employees at Flower will also be interviewed to provide insights into the firm's operations today. Finally, interviews will be conducted with people excelling in BESS development to understand what makes companies developing BESS successful and the requirements for developing a BESS.

2.3.1.2 Interviews

As this research leans towards qualitative data due to the complexity of the subject every question was asked to an industry expert. Among the qualitative data collection methods, interviews played a significant role. Thus, designing an interview guide became crucial to explore predetermined topics thoroughly. Employing semi-structured interviews was deemed optimal as they offer flexibility and encourage expansive dialogue, fostering discussions rather than rigid questioning (Tracy, 2020).

The interviews at the case company were conducted in two rounds. The initial round served as an introductory session aimed at acquiring information about the company. Subsequently, the second round placed a more pronounced focus on theoretical questions derived from the frameworks applied in this thesis. Various interview guides tailored for different interviewees can be found in Appendix A. Furthermore, several aspects were introduced to the interviewees before each session.

- ➢ To ensure confidentiality and enhance interviewee comfort, all interviews were conducted anonymously and will be referenced as interviewees 1 to 11
- ➢ The interviewees were briefed on the purpose of the research to provide a clear understanding of its scope.
- ➢ Recordings were made to accurately capture and reproduce the interview content.
- ➢ All questions posed during the interviews were voluntary, allowing participants the option to respond as per their comfort level and providing confidence for us that the answers would be honest.

- ➢ After the interviews, transcriptions were sent to the participants for error identification and correction.

The interviews were mostly conducted via online platforms like Google Meet, with in-person information also adding further details. These interviews have been recorded, transcribed, and translated from Swedish to English.

In total 13 interviews were conducted with 11 different interviewees. These included BESS industry experts, university personnel, flower employees and board members, so a wide range of personnel from varying backgrounds in order to secure a higher degree of trust in the thesis.

2.3.2 Literature Review

A literature review serves multiple purposes: it provides a foundational understanding of a subject area, contextualises new research, and identifies gaps in existing literature (Hempel, 2020). The assessment of a study's value is closely tied to prior research. The search for relevant literature is a recurring process, often yielding new references and keywords that contribute to successive iterations. This iterative approach continues until the literature review is complete. Along the way, it fosters the acquisition of new subject knowledge, which helps further define the chosen purpose and problem formulation. The literature review should ensure the incorporation of vital theories from relevant research and the currency of knowledge in the selected subject field (Saunders et al., 2007).

When dealing with the quality of research the purpose of the thesis is to be as scientifically grounded as possible. Therefore to gain knowledge about different aspects of BESS, Flower Infrastructure Technologies AB, scenario planning, development of resources, technology strategy and knowledge bases around high-tech services a literature study was done. The literature review of the implementation of these tools primarily focused on product management.

The search engines used for the literature study were LUB-search, Lund University internal search engine, and Google Scholar.

The selection of theories and models to include in the thesis was made based on several different criteria. More recent published literature was preferred, especially related to BESS as it is a research area that is in a developing stage. In the older models, the original research paper was seen as the groundwork but if there were later additions to the models or amplifications these were also often included. Research that was industry-specific for industries considered very different from the energy industry, or markets very different from the Swedish, was often not included. Besides using search engines dedicated to articles and research, the search engine Google was used along with books on the topic. When books were used, the original authors of the scientific publications were preferred or else if there were no later publications the books given out at LTH for courses including these subjects were used. Additional sources of information were handed to the authors by Flower through internal communication or by publicly available sources on Flower. These include internal sources about company structure, processes, products, and financials among others.

2.4 Scenario Planning

To provide a sufficiently well thought-out future day analysis, in line with the purpose of the thesis '*scenarios planning*' was used. Scenario planning is a well-proven way of dealing with uncertainties of the business environment and coordinating decision-making for the short-, medium- and long-term future of the company. Scenario planning is a way of creating future concepts in which a feedforward scenario is generated from which scenarios, trends and/or prognoses can be analysed and present the future. This is highly suitable to this thesis and will be further elaborated on in part 3.5. (Bandholm & Lindgren, 2009)

The scenarios in our thesis will be based on the theory method outlined in Chapter 3, and these scenarios will be presented in the future-day analysis in Chapter 7.

3. Theory

This chapter presents the relevant theories and models that were needed to create the framework used in this thesis. It contains an overview of the 5 major theories used and the sub-theories that were also integrated into the framework to complete the purpose of this thesis.

3.1 Introduction

To fulfil the purpose of this thesis, which was described in 1.2 '*The purpose of this study is to describe and analyse the development of high-tech services and the consequences for the technology acquisition and knowledge basis in a company within the energy sector in Sweden'*, various theories were explored. The value proposition was seen as fundamental to understanding what value the company provides. The "three levels of product" model was therefore used to grasp the fundamental value of the company's offerings and the value processes of its services. Additionally, the Resource-Based View (RBV) was selected for its effectiveness in providing a comprehensive understanding of the company's current and future resources and capabilities. Within the RBV theory, the concepts of core competency and VRIO were also further examined as integral sub-models to fully exploit the RBV theory. To comprehend the acquisition process and integrate the aspects of value creation, along with the utilisation of various resources and capabilities, Ford's technology strategy model was incorporated along with the expansions by Davenport. Primarily Davenport extensions of the acquisition modelling and the use of complexity theory were used. The mentioned models will in consultation combine the static view of the company's current operations, with the dynamic processes contributing to future value creation. This will also provide insights into how the different models of the proposed framework will provide feedback to each other. Therefore these three models will give a sound understanding of the static operations of how the company operates today, how it will operate if it implements the high-tech acquisitions, as well as, expand the dynamics of what the changes will be and what consequences they will convey.

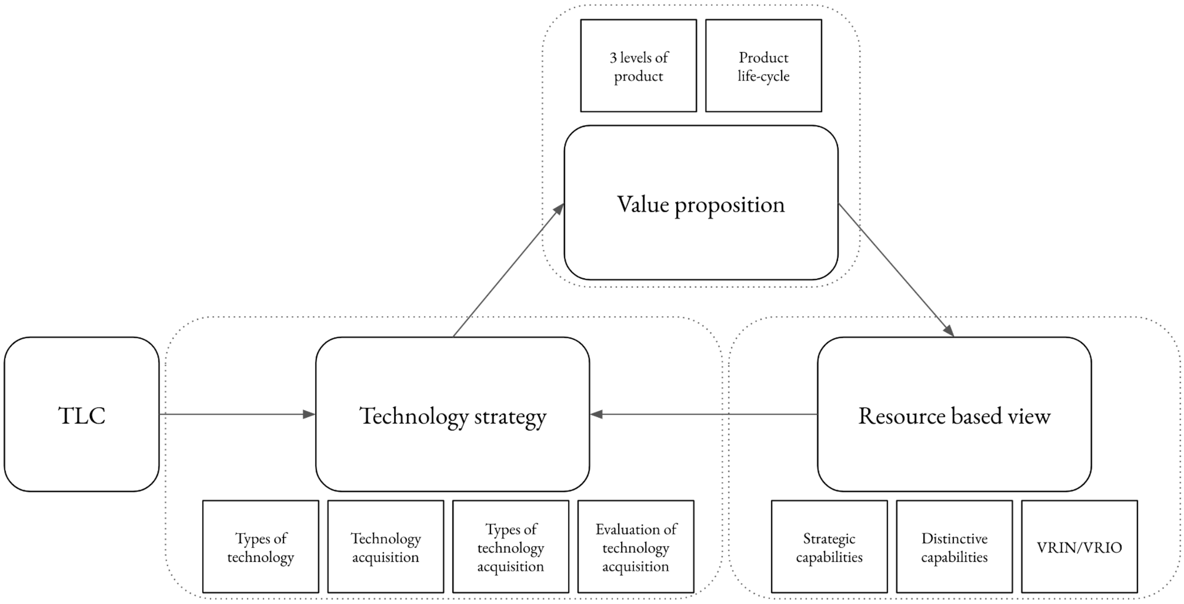

Figure 2 - Framework used in the current analysis

To then incorporate these models into the method strategy of this thesis (described in Chapter 2.2) the implementation of these models will first be used in the current analysis and then multiple scenarios will be decided with the help of scenario planning. In the future analysis, scenario planning is used in order to create cases which will be introduced later in the thesis. These scenarios will then be evaluated with the same help as the current analysis, from which, the gaps between the current analysis and the future can be clearly evaluated.

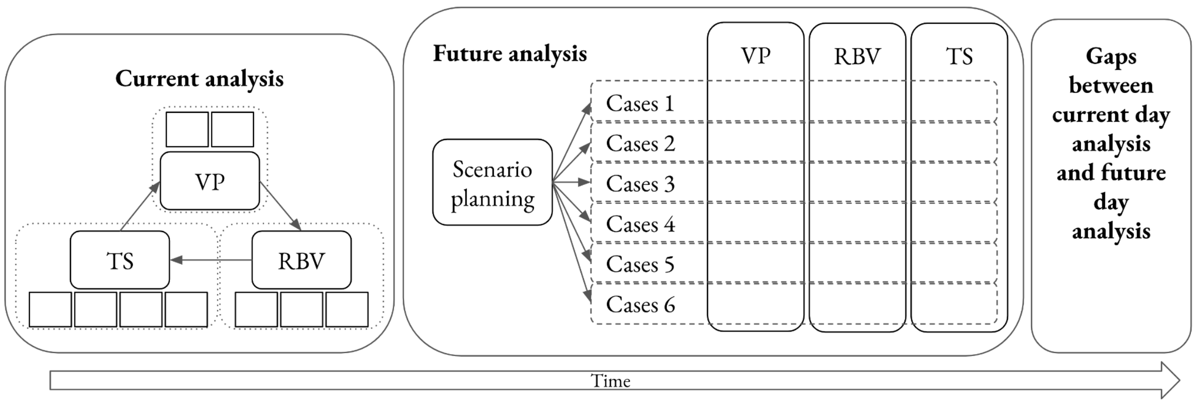

Figure 3 - Overview of how the different models will be used in the current and future analysis implemented into the research strategy

The following parts in this chapter therefore aim to provide essential knowledge of these theoretical models for those unfamiliar, facilitating a clear understanding for subsequent analyses, while also offering insights into the purpose and application of these models.

3.2 Value Proposition

The concept of the value proposition has its origins in a staff paper published by McKinsey in the late 1980s. In this paper, Lanning and Michaels (1988), posit that a successful strategy involves taking actions that result in a sustainable competitive advantage. The paper argues that a business unit promises value, a combination of benefit and price, to its customers. Thus, it offers a value proposition. To achieve a competitive advantage, the authors emphasise that a superior value proposition backs up a winning strategy. In a subsequent McKinsey staff paper (2000), Lanning and Michaels provided further insight into this matter, defining a superior value proposition as *'a clear, simple statement of the benefits, both tangible and intangible, that the company will provide, along with the approximate price it will charge each customer segment for those benefits'*. The definition of value proposition has been evolving ever since it was first introduced, and may differ between authors, but one thing remains the same - a strong value proposition is key to designing a winning marketing strategy (Kotler, Armstrong & Parment, 2016). Kotler, Armstrong and Parment (2016), argue that once the value proposition is clearly defined, the company can proceed with creating a need-satisfying market offering, i.e. a product or service. Before delving into the models that help understand and define a value proposition, therefore there first needs to be a definition of a product in this thesis.

3.2.1 Definition of a Product

In a broad sense, a product encompasses anything presented to a market with the aim of capturing attention, securing acquisition, enabling use, or facilitating consumption to meet a desire or need. Products encompass not only tangible physical objects but also extend to services, events, individuals, locations, organisations/employers, ideas, or combinations thereof. Services represent products characterised by intangible offerings, involving activities, benefits, or satisfactions available for purchase. (Kotler, Armstrong & Parment, 2016). With this definition, services are considered a type of product, making models like the three levels of a product and product life cycle directly applicable to services as well.

3.2.2 The Three Levels of a Product

How is the value proposition defined from a company's market offering? With a product view in mind, Kotler, Armstrong and Parment (2016) introduce us to *the three levels of a product*, which is a tool to fully grasp the value proposition. The authors conceptualise products and services across three distinct levels (see Figure 4 below), with each level contributing incremental value to the consumer. The foundational level, *core benefit or service,* delves into the essential question of what intrinsic value the buyer is truly seeking. An example of this level of the model can be transportation. Whether you use a bicycle, a car, or public transportation, the core benefit is the ability to get from point A to point B. At the second level of the model, the core benefit is transformed into the *actual product.* Continuing with the transportation example, the actual product becomes a car. In this case, it's not just any car; it's a specific make and model with features like comfort, safety, and fuel efficiency. The tangible features and attributes make up the actual product. The third level, *the augmented product,* builds upon the core benefit and actual product by incorporating supplementary consumer services and advantages (Kotler, Armstrong & Parment, 2016). At this level, the car extends beyond its physical features. The augmented product includes additional services and benefits like convenience, ease of use (through a mobile app), and the option for a more personalised experience. In essence, consumers perceive products as intricate bundles of benefits tailored to meet their diverse needs. Consequently, product developers must meticulously identify the core customer value sought by consumers, proceed to design the actual product and explore avenues to augment it. This holistic approach aims to craft a customer-centric experience that is both satisfying and aligned with consumer expectations (ibid.).

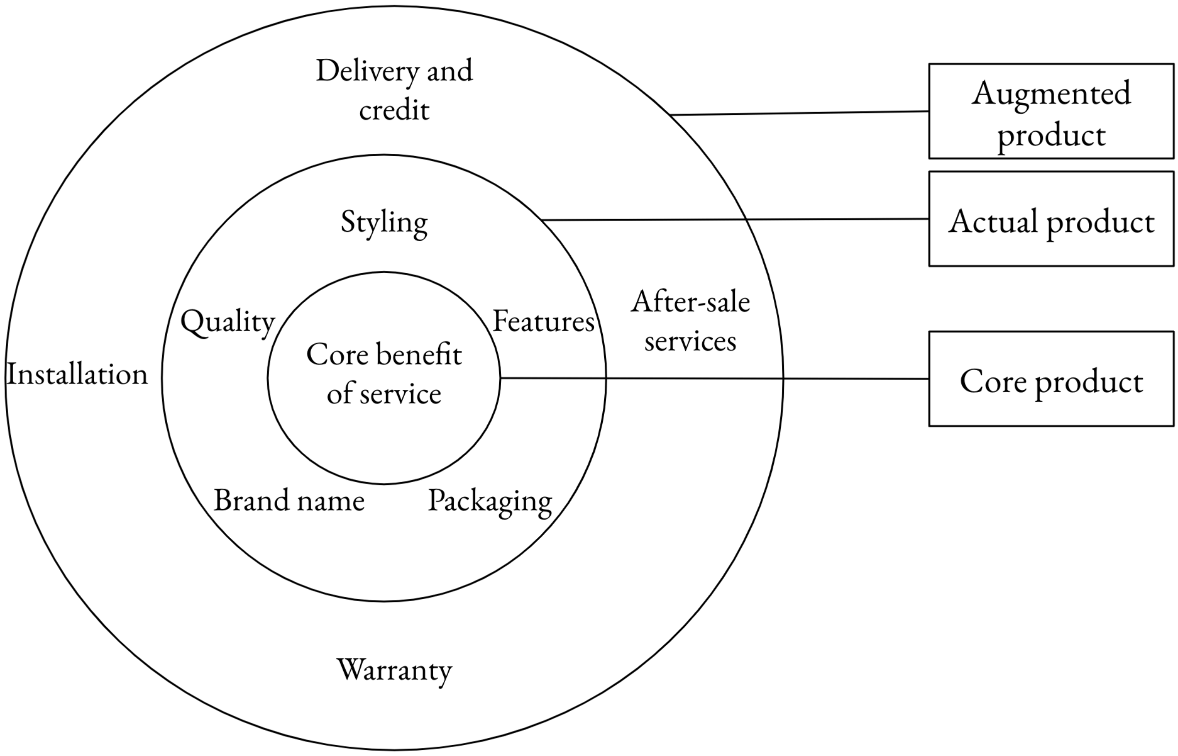

Figure 4 - The model of the three levels of a product (Kotler, Armstrong & Parment, 2016)

3.2.3 Product Life Cycle

The product life cycle (PLC) encompasses five stages a product undergoes during its lifespan (Kotler, Armstrong & Parment, 2016):

1. **Product development** initiates when the company discovers and cultivates a new product concept. During this stage, the company incurs mounting investment costs without generating any sales.
2. **Introduction** signifies a phase of slow sales growth as the product enters the marketplace. Typically, no profits materialise during this stage, given the substantial expenses associated with product introduction and marketing.
3. **Growth** is when the market acceptance and profits are rapidly increasing.
4. **Maturity** is a period when the product has achieved acceptance by most buyers and profits are starting to decrease.
5. **Decline** is the last stage and during this period sales fall off and profits decrease.

Figure 5 below illustrates the Product Life Cycle (PLC) for a product, depicting the revenue from its introduction to its decline over time. The product development stage is not shown in the figure thus there is no revenue during this period. Not all products traverse all phases; some linger in maturity, while others experience swift introductions and discontinuations. The PLC is versatile and applicable to product classes (e.g., fossil fuel-powered cars), forms (e.g., small SUVs), and brands (e.g., Mini Countryman). Typically, product classes have lengthier life cycles than specific forms or brands. Beyond tangible products, the PLC concept extends to styles, fashions, and fads. Styles endure for generations, with cycles of resurgence, while fashions evolve gradually and fade after a period. Fads are marked by temporary surges in sales, driven by immediate popularity. Understanding and strategising around the PLC is crucial for effective marketing planning and product management. (ibid.)

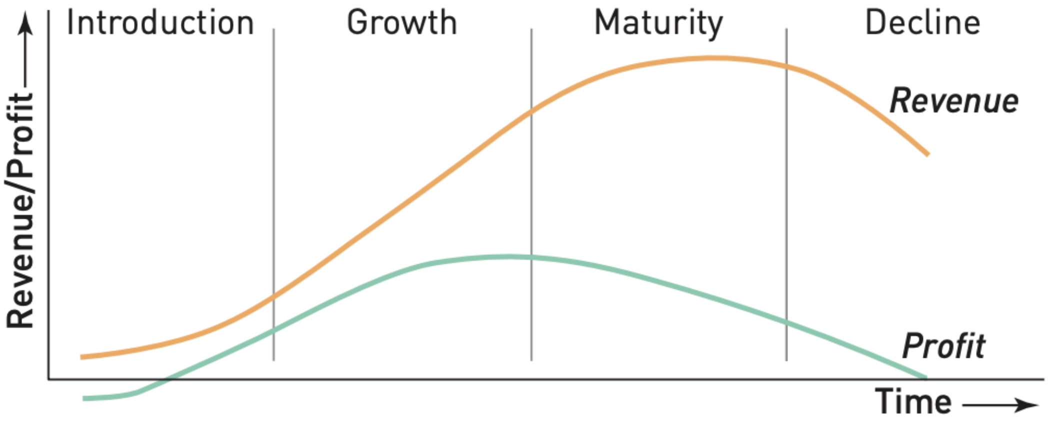

Figure 5 - The product life cycle. (Kotler, Armstrong & Parment, 2016)

3.3 Resource-Based-View

In a competitive market, it's often not the environmental conditions that set companies apart but the strategic capabilities they've cultivated in terms of resources and competencies. These strategic capabilities play a pivotal role in determining outcomes. The resource-based view (RBV) is therefore used as a model to help managers comprehend their organisations and from this gain insights into how their organisations differ from their competitors. More specifically it also helps them to understand in what way their company is achieving competitive advantages or superior performance against their competitors (Barney, 1991).

3.3.1 Value-Creating Strategy

In the RBV theory, just as in this thesis, competitive advantage is defined as "*the implementation of a value-creating strategy not currently adopted by any current or potential competitors*" while sustained competitive advantage goes further, requiring not only uniqueness but also "*an inability of other firms to duplicate the benefits of the strategy*"' (Barney. 1991). The definitions consider both current and potential competitors in an industry. The concept of sustained competitive advantage(s) is not time-dependent but focuses on the enduring inability of competitors to duplicate the advantage(s). It is emphasised that sustained does not mean eternal. As unanticipated industry changes, termed "*Schumpeterian Shocks*", can alter the value of a previously advantageous strategy. Instead, it means that for prolonged periods it will have a high performance for the company (Barney, 1986a; Barney, 1991; Rumelt & Wensley, 1981). On top of this, the firm's competition is assumed to include not only all of its current competitors but also potential competitors poised to enter an industry at some future date. Thus, a firm that enjoys a competitive advantage or a sustained competitive advantage, is implementing a strategy not simultaneously being implemented by any of its current or potential competitors (Barney, McWilliams, & Turk, 1989).

Going back to the model, The essence of the RBV can be summarised as, "*the understanding of competitive advantage and superior performance of an organisation which can be attributed to the distinctiveness of its capabilities*." However, the terminology may vary depending on context, but the two fundamental questions that are used in the model are as follows: (Johnson, Whittington & Scholes, 2012)

1. What constitutes strategic capabilities? (will be discussed in 3.3.2)
2. How do strategic capabilities contribute to gaining a competitive advantage and achieving superior performance? And can we diagnose these strategic capabilities? (will be discussed in 3.3.3-5)

3.3.2 What Constitutes Strategic Capabilities?

To understand the models the first question needs to be addressed: '*What constitutes strategic capabilities?*' Strategic capabilities refer to an organisation's attributes that contribute to its long-term survival and competitive advantage. These capabilities encompass two primary aspects: resources and competencies where resources include all assets, such as organisational processes, firm attributes, information, knowledge etc. that an organisation possesses or can access, including those from partners or suppliers. The competencies, on the other hand, represent what an organisation excels at doing from these resources. (Barney, 1991; Barney 2013; Johnson, Whittington & Scholes, 2012) In simple terms, resources can be seen as what an organisation has and that competence is what you can do with it (Johnson, Whittington & Scholes, 2012). An important part of understanding the question of what constitutes strategic capabilities is that resources are undoubtedly valuable, but their worth is realised through competencies. The efficiency and effectiveness of an organisation's physical and financial resources, as well as its human capital, are dependent not only on their existence but also on the systems and processes managing them, relationships with customers and suppliers, and the collective experience and learning about what works well and what does not. (Barney, 1991; Barney 2013; Johnson, Whittington & Scholes, 2012).

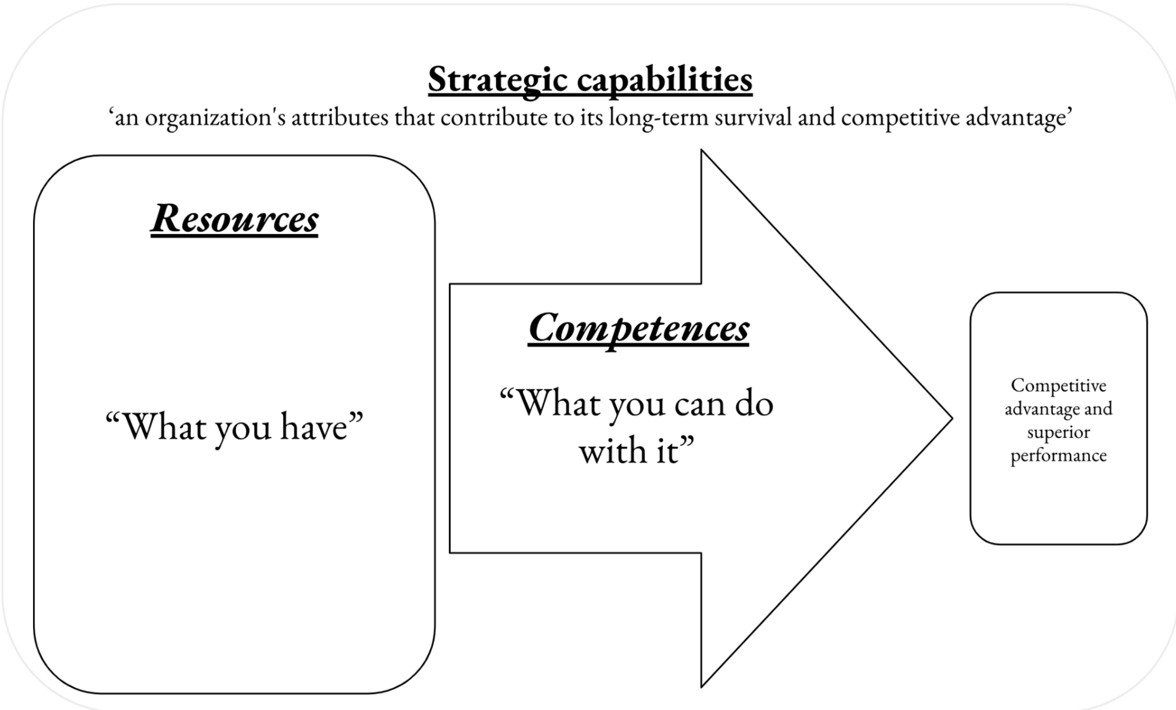

Figure 6 - Topology of Strategic Capabilities

3.3.2.1 Categorisation of Resources

When discerning these resources they are often categorised into four categories, financial, physical, human or organisational capital. Financial capital includes all the different money resources that firms can use to conceive of and implement strategies, for example, capital from entrepreneurs' equity holders, bondholder stakes or financial capital. Physical capital on the other hand includes the physical technologies that are used by the firm, in other words, what a person can touch or point directly at. For example, this includes the firm's plant and equipment, geographic location, products and raw materials. Human capital is what the individuals who work at the company bring. This might for instance include the knowledge, training, experience, judgement, intelligence, relationships, education and/or insights of individual managers and workers at the firm. Organisational capital is finally the attribute of the whole of the organisation and its surroundings. For instance the company structure, informal relations among groups within the firm and the relationships between the firm and its environment (Barney, 2013)

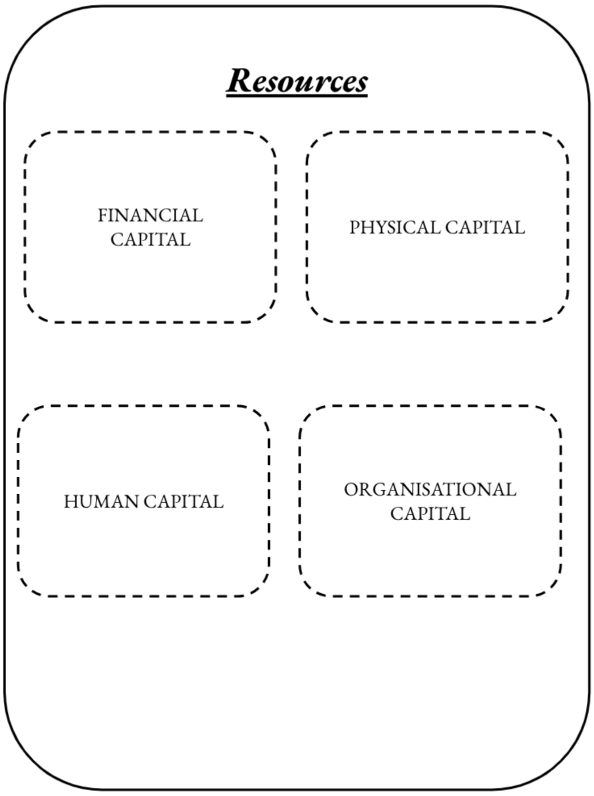

Figure 7 - Strategic capabilities with the 4 types of resources used in this thesis

3.3.2.2 Categorisation of Competencies

Knowing what resources are, how do they correspond back to the capabilities? An important aspect of the capabilities is their differing importance for organisations to achieve long-term success, their strategic capabilities must adapt and evolve continually. Economist David Teece therefore introduced the concept of dynamic capabilities, which refers to an organisation's ability to renew and recreate its strategic capabilities to meet the changing demands of the environment. This adaptation is essential to maintain alignment with incentives, control costs, ensure quality, optimise inventories, and prevent the erosion of capabilities that once granted competitive success. These capabilities can take the form of both formal organisational systems like recruitment and management development processes and significant strategic moves like acquisitions or alliances, through which new skills are acquired and developed. Successful acquisitions can offer insights into how to integrate the acquired entity into the organisation, capturing synergies and learning opportunities (Barney, 1991; Barney 2013; Johnson, Whittington & Scholes, 2012). Dynamic competencies often have roots in less formal aspects of organisations, including decision-making processes, personal relationships, and entrepreneurial and intuitive skills (Barney 2013). Another kind of competence is the threshold competence which can be seen as the fundamental stepping stones that the company needs to cross in order to create strategic capabilities and act as threshold barriers for potential (or actual) competitors. Threshold competence is therefore the prerequisite for an organisation to compete in a given market and achieve parity with competitors. Without these capabilities, the organisation wouldn't be able to sustain itself over time. Many start-ups face this challenge, as they struggle to obtain the necessary resources needed to maintain competitiveness. However, it's important to note that threshold capabilities, on their own, do not create advantages or the basis for superior performance. Here's where the distinctive capabilities come in. These are the true advantages that a company generates against its competitors and stem from distinctive resources that underpin competitive advantage and cannot be easily imitated. These competitive competencies can also represent unique ways in which a company generates distinct advantages in resource utilisation or value creation that competitors cannot replicate. According to Hamel and Prahalad, these distinctive competencies are often a combination of various constituent skills and technologies, rather than a single discrete skill or technology. This revised analysis provides a more accurate and detailed examination of the RBV-based modelling of strategic capabilities. It offers a deeper understanding of how these capabilities influence a company's competitive advantage and performance. (Barney 2013; Johnson, Whittington & Scholes, 2012)

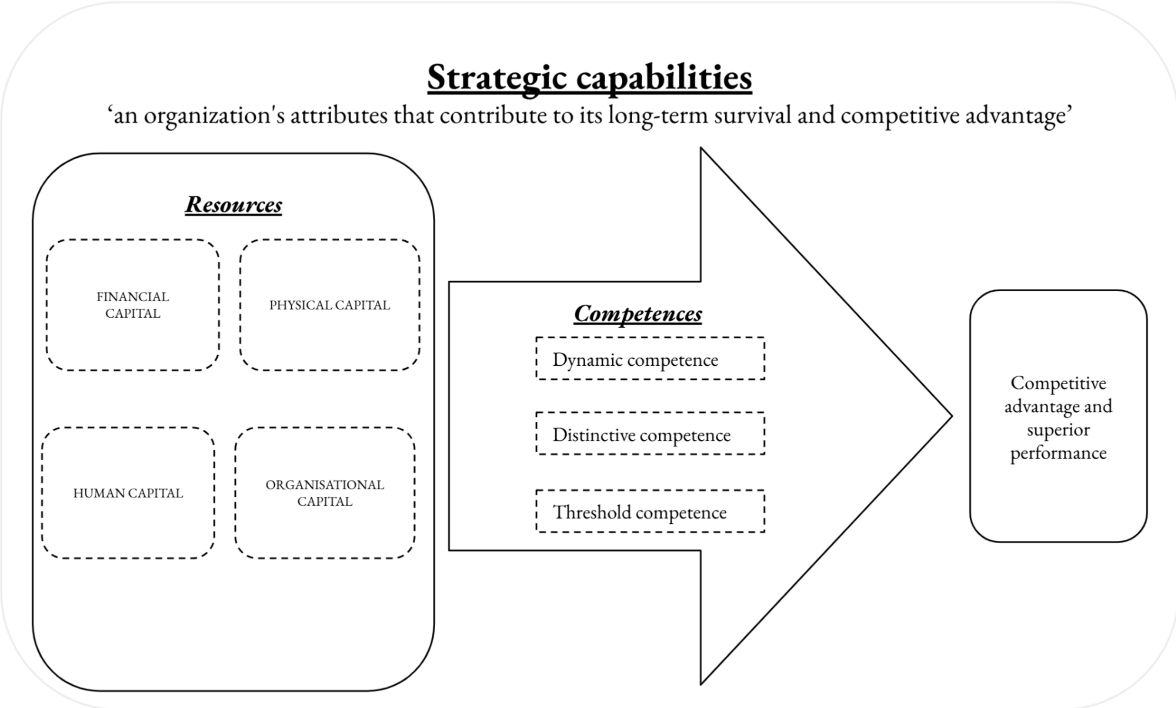

Figure 8 - Topology of capabilities, resources and competencies

These dynamic partitions—dynamic, distinctive, and threshold—are not confined solely to competencies; they can also extend to the interpretation of resources. The motivation behind these partitions within resources mirrors that within capabilities, albeit considering them as resources instead. (Barney 2013; Johnson, Whittington & Scholes, 2012)

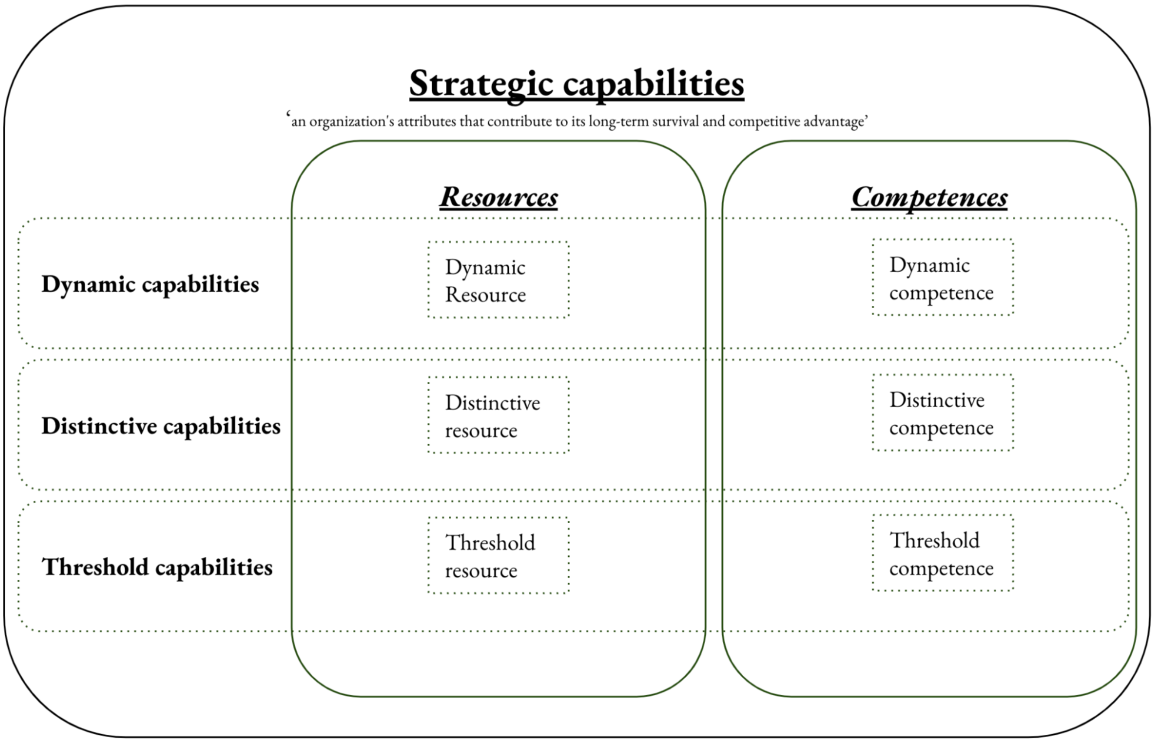

Figure 9 - The connection between strategic capabilities, resources, competencies, dynamic capabilities, distinctive capabilities and threshold capabilities

3.3.3 Core Competencies

As there are so many competencies here to be analysed, the company needs to explore which of these should be explored deeper. This drove Prahalad and Hamel to further elaborate on what separates the distinctive capabilities of a firm from the rest and elaborated that these should be sorted as the firms' dominant logic (Branley, 2013). This was later further expanded by Hamel and Prahalad (1990) by distinguishing the company's '*core competencies*'. The elaboration here was that the core competencies are a linked set of skills, activities and resources that together deliver customer value while differentiating the business from its competitors.

The focus on core competencies is a way of creating unique, integrated systems that reinforce fit among a firm's diverse production and technology skills. It's primarily used to clarify what the strengths are that support your competitive advantages. In order to do this a company needs to identify core competencies which it does by answering the following questions (Prahalad & Hamel, 1990):

➢ How long could we dominate our business if we didn't control this competency?

- What future opportunities would we lose without it?
- Does it provide access to multiple markets?
- Do customer benefits revolve around it?

At least three tests can be applied to identify core competencies in a company. First, a core competence provides potential access to a wide variety of markets. Second, a core competence should make a significant contribution to the perceived customer benefits of the end product. Finally, a core competence should be difficult for competitors to imitate. And it *will* be difficult if it is a complex harmonisation of individual technologies and production skills. A rival might acquire some of the technologies that comprise the core competence, but it will find it more difficult to duplicate the comprehensive pattern of internal coordination and learning. (Prahalad & Hamel, 1990)

From these questions a company can get an understanding of what core competencies the company has, after this they can decide on what they should do about these. Several ways have been shown an impact on the core competencies, some of them being (Prahalad & Hamel, 1990):

- Decentralisation, which makes it difficult to focus on core competencies.
- Diversification also makes it harder to focus on what you're actually good at.
- More usage of a certain set of skills improves the know-how of that skill and can thus improve a company's core competency, however, these competencies also need to be nurtured and protected.
- Outspending your competitor does *not* mean that you will cultivate core competence.
- Vertical integration doesn't necessarily contribute to more core competencies.
- Another way of losing core competencies is forgoing opportunities to establish competencies that are evolving in existing businesses.
- There are trends of companies having unwittingly surrendered core competencies when they cut internal investment in what they mistakenly thought were just "cost centres" in favour of outside suppliers.
- The loss of core competencies is also difficult as they only partly can be calculated in advance.
- Since core competencies are built through a process of continuous improvement and enhancement that may span a decade or longer, a company that has failed to invest in core competence building will find it very difficult to enter an emerging market, unless, of course, it will be content simply to serve as a distribution channel.
- The manufacture of core products for a wide variety of external (and internal) customers yields the revenue and market feedback that, at least partly, determines the pace at which core competencies can be enhanced and extended.

- ➢ Companies that attempt to build market share by relying on the competitiveness of others, rather than investing in core competencies and world core-product leadership, risk losing their own core competencies

3.3.4 VRIN/VRIO

Now with the first question of what constitutes strategic capabilities answered, this now leads us into the second earlier stated question, *'How do strategic capabilities contribute to gaining a competitive advantage and achieving superior performance? And can we diagnose these strategic capabilities?'* There are several ways of identifying these capabilities internally, one way is through value-chain analysis which is the way of discerning how a resource is internally improved and later exploited into something of higher value. In these models, there are several ways of exploring the different resources and capabilities of the company. In order to do this, the VRIO model will be used in this thesis.

The VRIO model is a way of diagnosing capabilities to differentiate which of them are generating sustainable competitive advantage(s). This is done by evaluating four attributes, which act as the foundations of which of the company's capabilities can hold the potential to act like a sustained competitive advantage against the competitors. These are (1) it must be **V**aluable, which means that it exploits the opportunities and/or neutralises threats in a firm's environment, (2) it must be **R**are among a firm's current and potential competitors to acquire it, (3) it must be **I**mperfectly imitable, that is to say that there aren't any good alternative to the resource and finally, (4) there are the **O**rganisation must be strategically positioned in order to use these 3 aspects. These can be seen as the foundations of how the diagnosis can be done and will act as the foundation of how company resources will be analysed. Further elaboration of these 4 aspects will thus be further elaborated on below. (Barney, 2013; Johnson, Whittington & Scholes, 2012)

Valuable

Analysing the value of a firm's capabilities is a critical step in determining their potential as sources of competitive advantage. The worth of a resource is contingent on its ability to contribute to improved efficiency and effectiveness in strategy conception and implementation. If a resource does not play a meaningful role in the value-creation process, it lacks a fundamental purpose within the company. Such capabilities act as mere extras, offering no tangible value in the value-creation process. It's crucial to understand how a resource adds value and past contributions do not guarantee future relevance. Changes in the firm's attributes or the external environment may alter the suitability of a resource over time. (Barney, 1991)

Rare

After identifying valuable capabilities, the next crucial step is evaluating their rarity. A resource's rarity is pivotal; if it's not rare or easily attainable, your competitive advantage will likely be short-lived. Remember here the introduction of a competitive advantage, in order to be considered a competitive advantage, it's 'not time-dependent but focuses on the enduring inability of competitors to duplicate the advantage'. This can't be the case if a resource is easily accessible, as then, competitors will swiftly incorporate it into their value chain. The same principle applies to bundles of capabilities used for strategy implementation. Some strategies demand a specific mix of physical, human, and organisational capabilities. If this resource bundle isn't rare, numerous firms can implement the same strategies, diminishing their competitive advantage, even if the capabilities are valuable. Notably, common but valuable capabilities can still ensure a firm's survival by establishing competitive parity in an industry, where no single firm gains a competitive advantage, but all increase their chances of economic survival. Determining how rare a valuable resource must be for a competitive advantage is challenging. While absolutely unique capabilities generate a competitive advantage, even a small number of firms possessing a particularly valuable resource can lead to a competitive advantage, as long as it's less than what's needed for perfect competition dynamics in the industry. (Barney, 2013; Johnson, Whittington & Scholes, 2012)

Imperfectly Imitable

Valuable and rare capabilities can initially provide a competitive advantage, even leading to a first-mover advantage. However, for this advantage to be sustained, these capabilities must also be imperfectly imitable - that being that the capability can't be replaced by something just like it (Lipman & Rumley, 1982; Barney, 1986b; Barney, 1986c). The analysis of this part involves evaluating how competitors might imitate a company, considering two main approaches: direct duplication and substitution. (Barney, 2013; Johnson, Whittington & Scholes, 2012)

Direct duplication entails competitors replicating a resource, necessitating an assessment of rarity and entry barriers for competitors. It is crucial to understand whether competitors would gain equivalent value as the original company. If the cost of direct duplication exceeds the cost of developing these resources and competencies, it will even act as a competitive disadvantage for the imitating firms. (Barney, 2013; Johnson, Whittington & Scholes, 2012)

Alternatively, competitors may opt for substitution, where they replace a costly-to-imitate resource with something else. This process might yield new knowledge, status quo or in a worse case lead to cost disadvantages, especially if the original company has developed a resource of unique value. The sustainability of competitive advantages hinges on the presence of substitute capabilities and whether imitating firms face a cost disadvantage in acquiring them. If substitutes are available at a lower cost, the competitive advantage is likely to be temporary. However, if no substitutes exist or their acquisition cost is higher, competitive advantages can be sustained. This might be for example due to the fact of unique historical conditions, causal ambiguity, perhaps due to invisible assets, organisational capabilities, social complexity or patents (Barney, 2013; Johnson, Whittington & Scholes, 2012)

Organisation

A firm's potential for competitive advantage depends on the value, rarity and imitability of its capabilities. However, to fully realise this potential a firm must be organised in order to exploit its capabilities. These observations lead to the '*question of organisation*': "*Is a firm organised in order to exploit the full competitive potential of its resources and capabilities?*" (Barney, 2013; Johnson, Whittington & Scholes, 2012)

Numerous components of a firm's organisation are relevant to the question of organisation, including its formal reporting structure, its explicit management control systems, and its compensation policies. These components are often called '*complementary resources*' and '*complementary capabilities*' because they have limited ability to generate competitive advantage in isolation. However, in combination with other resources and competencies, they can enable a firm to realise fuller competitive advantage potential. (Amit & Schoemaker, 1993; Barney, 2013; Johnson, Whittington & Scholes, 2012)

3.3.5 Applying the VRIO Model

Now that the VRIO model's aspects are introduced, the next logical step is their application. This involves evaluating the resources and competencies on four key criteria: is it... valuable, rare, costly to imitate and is the organisation fully exploiting the resources and/or competencies to their full potential? The outcomes of this assessment determine the nature of the competitive advantage, expected economic performance, and its impact as a weakness or strength within the organisation. This can be done by several means but by Barney (2013) this is done by selectively analysing each capability in due turn. Is it valuable, then you move on to the question of if it's rare. If it's rare you continue to evaluate if it's costly to imitate. If a capability is perceived to not clear a certain aspect, each of the following parts is also ranked as false. This comprehensive evaluation is summarised in Figure 10, illustrating that the more aspects the resource fulfils, the more beneficial it is for the firm. (Barney 2013)

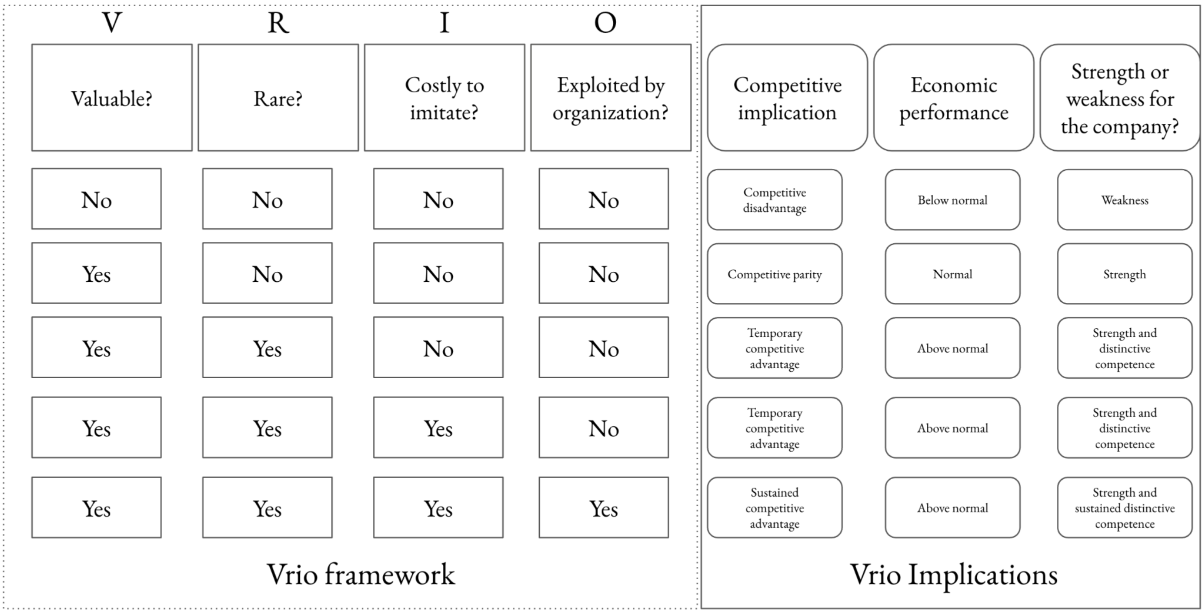

Figure 10 - The relationship between the VRIO model and competitive implication, economic performance, as well as, strengths and weaknesses for the company

3.4 Technology Life Cycle

Before delving further into the exploration of the technology life cycle and technology strategy (in Chapter 3.5) it is imperative to establish a clear definition of technology. In literature there is confusion regarding this, thus definitions of technology may vary (Taylor, M. & Taylor, A., 2012). According to Schon (1967), technology is a tool, technique, product, process or physical equipment - which is used to extend human capabilities. Similar to this, Drejer (2000), underscores both the tangible and intangible aspects of technology within a company, acknowledging the importance of human skills and experiences. Heffner and Sharif (2008) categorise technology into four dimensions: "technoware" (tools), "humanware" (talents), "infoware" (facts), and "orgaware" (methods), showcasing its multifaceted nature. However, the definition of technology that will be used in this thesis is the one from Bohn (1994): technology is technical knowledge that organisations apply in order to enhance their ability to produce products and services. Bohn's definition of technology aligns with the purpose of this thesis and thus this definition will be used.

Having established a foundation by defining technology, a shift of focus can now be don to its dynamic evolution through the lens of the Technology Life Cycle (TLC). The TLC bears a striking resemblance to the PLC (discussed in Chapter 3.3.3) concerning the structure, shape and terminology of the two models. In the literature, the TLC and PLC are often misunderstood and are in many cases considered as the "same" thing. However, it is crucial to distinguish between these models as they are applied differently, showcasing distinct aspects. This differentiation is vital for leaders to make more informed decisions and can assist companies in anticipating impending technological shifts. (Taylor, M. & Taylor, A., 2012; Porter, 1985)

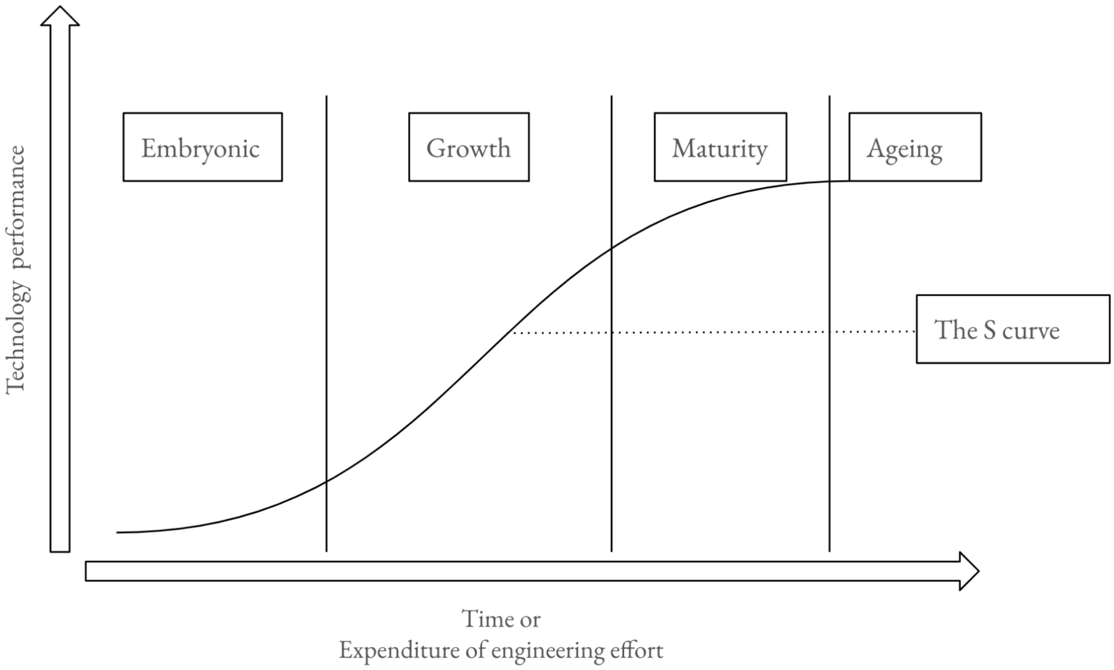

Figure 11 - Technology life cycle (Taylor, M. & Taylor, A., 2012)

Visualised as an S-shaped curve, the technology life cycle illustrates the technology's journey (see Figure 11 above). The model depicts technology performance over time, or over expenditure of engineering effort. Furthermore, it shows the four different stages the technology goes through, them being (Taylor, M. & Taylor, A., 2012):

1. **Embryonic** is the first stage of a new technology's journey, where market share is low and there are high levels of uncertainty.
2. **Growth** is the next stage, in which product design stabilises, production equipment becomes more specialised and entrants decrease - which all leads to a producer shakeout.
3. **Maturity** stage signifies a period where the technology performance decreases and the entrants decrease even further.
4. **Ageing,** sometimes *decline*, is the last stage when the S curve flattens, and technological performance ceases to develop.

As Figure 11 illustrates, the S curve starts with a slow increase and is followed by rapid dissemination and adoption. During these early stages, there is considerable variability in the technology's application to different products. Then, as the technology matures, the primary focus transitions to optimising production processes. (Porter, 1985) After a technology enters the ageing phase, new technological breakthroughs can occur, evolving the technology. This phenomenon is often observed within a technological field, as illustrated by Figure 12 below (Skärvad & Olsson, 2015).

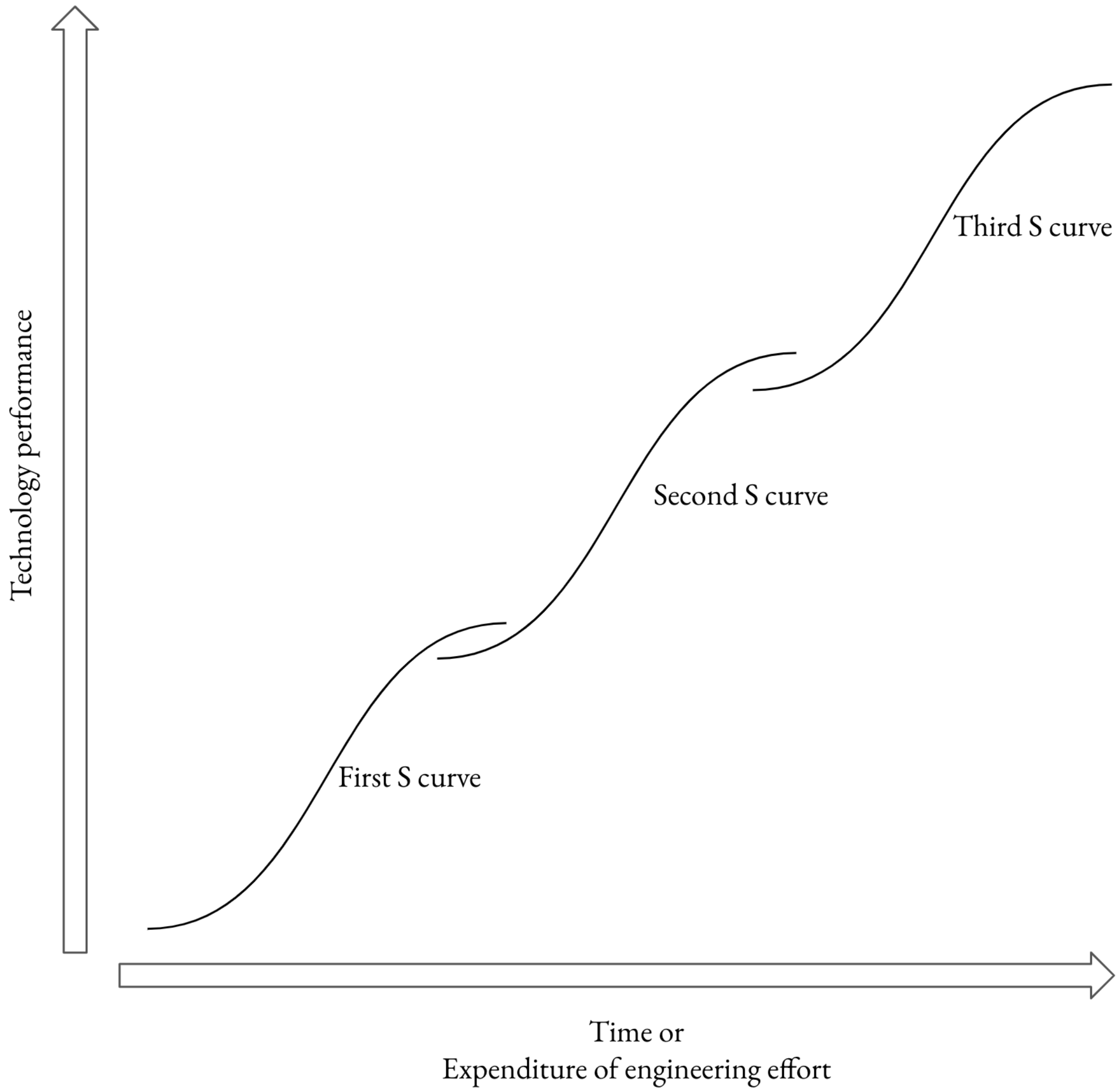

Figure 12 - Example of 3 S curves

3.5 Technology Strategy

The concept of technology strategy finds its origins in the late 70s' but this thesis will emphasise David Ford's publications from the 1980s and 1990s where he, alongside scholars like Richard Thomas, presented several explanations to assist companies in understanding what technology strategy is and how to use it (Adler, 1989; Ford, 1988, Ford & Thomas, 1997).

"Technology strategy encompasses the acquisition, management and exploitation of technological knowledge and resources by the organisation to achieve its business and technological goals." *(Solomon, 2001)*

Technology strategy is rooted in how companies manage their technological resources (resources are explained in 3.2). To create value, a company should focus on understanding its competencies and what it can derive from them, rather than solely concentrating on its current product offerings or what market they're in. This entails developing policies, plans, and procedures for acquiring, managing, and exploring knowledge and capabilities within the company. Embracing this perspective can open new horizons, allowing companies to envision what they might produce in the future as technology strategies primarily use a long-term perspective. In the realm of technology strategy, two main types of technology exist: product technology and production technology. Each comes with its own set of challenges but both existences are granted through the same three elements. Given that this master's thesis evaluates a service from a product, the discussion will primarily revolve around product technology. (Ford & Thomas, 1997; Ford, 1988)

The focus of technology strategy is often to move from ambiguity to clarity in regards to how technologies are used in the company. Therefore Ford formulated several questions that the company should be able to answer: (Ford, 1988)

- ➢ What are the technologies and know-how on which our business depends?
- ➢ What is our status in these technologies; do we lead or follow our competitors?
- ➢ How did we acquire these technologies; were they 'made' in-house or 'bought-in?
- ➢ Do we have a poor record in bringing 'home-grown' technologies to market?
- ➢ Is this poor performance due to inadequacies in research, development or commercialisation?
- ➢ Should we take steps to improve this performance, or accept our inadequacies and concentrate on searching for and acquiring new technologies from others?
- ➢ How does our technology position compare to that of our customers?
- ➢ What is the life cycle position of the technologies on which we depend?
- ➢ What are the emerging or developing technologies both inside and outside the company which could affect our current or prospective markets?
- ➢ Are the company's strengths in product or production technologies or both?
- ➢ Does the company achieve the optimum exploitation of the technologies we have?

In order to bring this into clarity it's essential to distinguish technology strategies from R&D strategies, which exclusively concern in-house technology development (Ford & Thomas, 1997; Ford, 1988). Inevitably, the strategy employed here will be a network strategy, where every resource within the company plays a part in the development of the company's technologies (Ford & Thomas, 1997). Consider the scenario where a company perceives itself as having expertise in car manufacturing but employs no mechanics. This limited perspective might lead to the oversight of making the car easy to repair. Consequently, to craft an effective technology strategy, the company must find ways to acquire these essential competencies. This necessitates the creation of a network among organisations, facilitating the acquisition of knowledge and an understanding of how to leverage and exploit these acquisitions (Ford & Thomas, 1997).

3.5.1 Categorisations of Technologies

In order to effectively compare these technological aspects, it is essential to have a clear understanding of the nature of each technology. Ford, recognising this need, introduced a classification into three distinct groups. The initial category encompasses 'Basic Technologies,' which serve as the foundational elements necessary for the company's seamless operation within its markets. A prime example of this is the production technologies that underpin the core product offerings. Conversely, if there exists a technology that truly distinguishes the company from its competitors, it can be regarded as a 'Distinctive Technology,' setting the company apart in a unique way, granting competitive advantages. The final segment pertains to 'External Technologies.' These technologies, such as those procured through sub-assemblies or consultancy, are developed by external entities. This strategic approach enables the company to leverage external expertise without diverting its internal focus core operations, where it excels. (Ford, 1988)

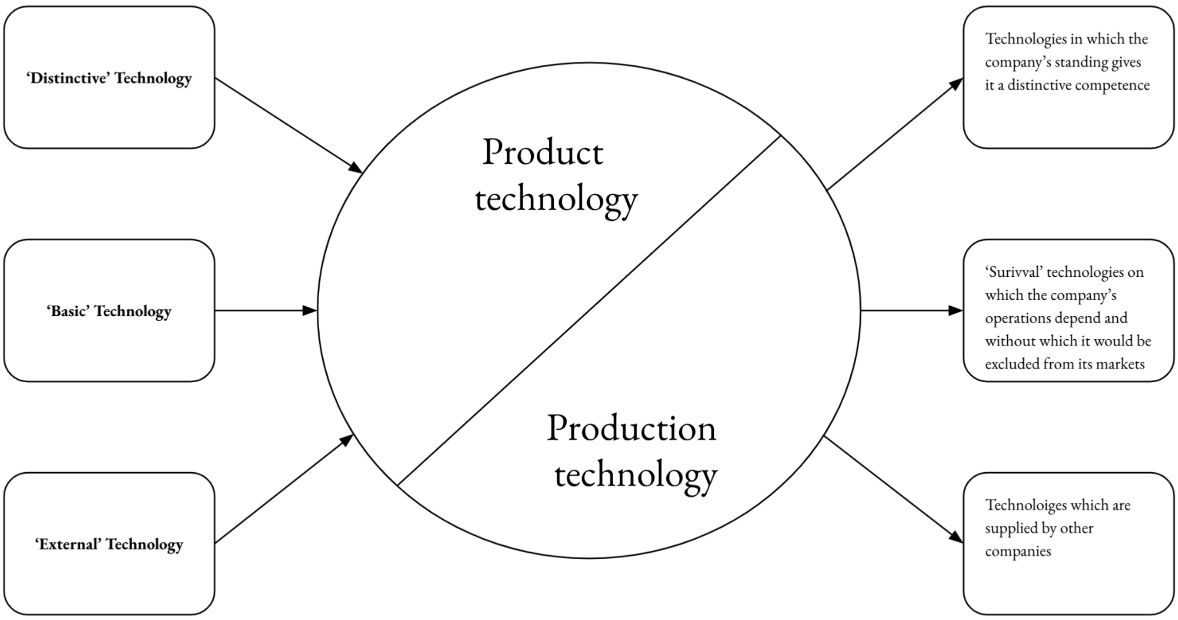

Figure 13 - The three types of technology (Ford 1988)

3.5.2 Elements of Technology Strategy

In order to clearly understand the aspects that create a well-functioning technology strategy three elements have to be understood. Firstly, the aspect of technology acquisition, sometimes called technology exploration, is the part of acquiring knowledge and ability, that is how you get new resources and capabilities into your company (Davenport, Campbell-Hunt & Solomon, 2003; Ford 1988). Second is the management part which asks the company if it's using the resources and capabilities inside the company in an optimal way.

Finally is the exploitation part that asks how are these resources and capabilities turned into profits (Ford, 1988)

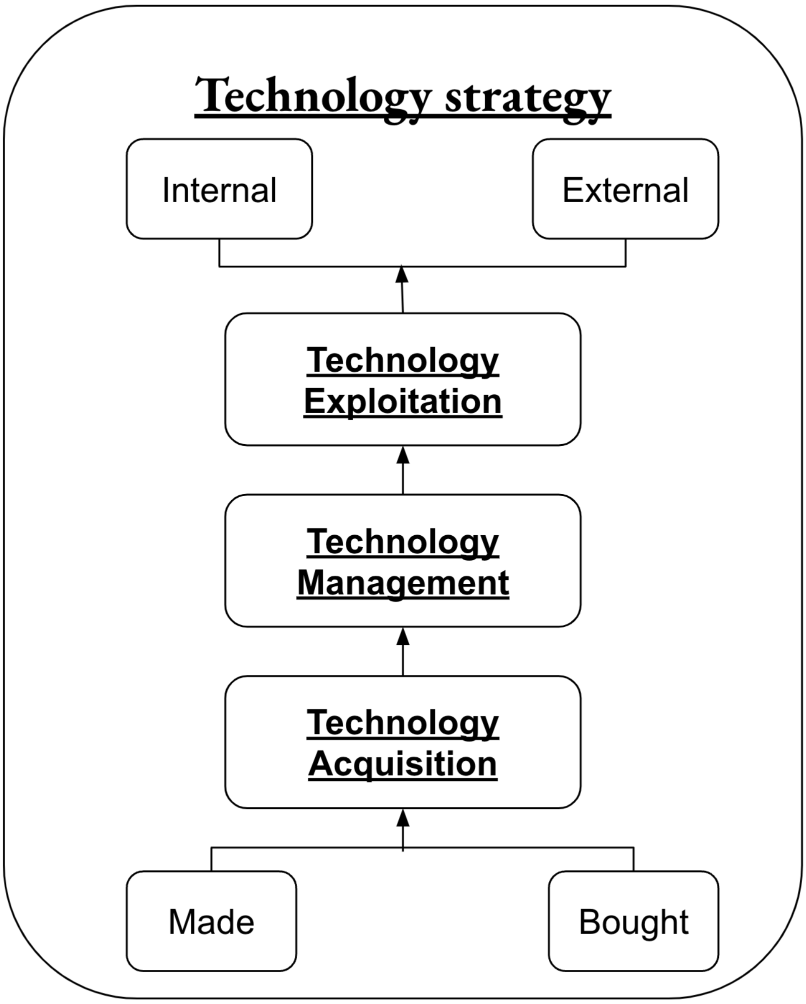

Figure 14 - The three elements of technology strategy (Ford, 1988)

3.5.3 Technology Acquisition

Of special interest in this report concerning the three elements of technology strategy is the aspect of technology acquisition as it clearly is linked to the purpose of the thesis. There are several ways of acquiring technology and these concepts have been deeply researched. One of the more prominent works is the one done by Davenport et al. (2003) where they extended the elements of technology strategy with the introduction of complexity theory. This brought a renewed emphasis on dynamic networks, introducing positive feedback loops and linkages into the system which provided a fresh lens through which technology procurement, management, and utilisation could be understood. They presented multiple alternatives for creating these feedback loops, such as:

- Vintage plough backs
- Market segment leverage
- Co-evolution with lead customers
- R&D plough back
- Co-evolution with technology partners
- Co-evolution with suppliers and
- International focus and ‘surviving the Gusher’.

A short introduction to every part will be presented below. (Davenport, Campbell-Hunt & Solomon, 2003)

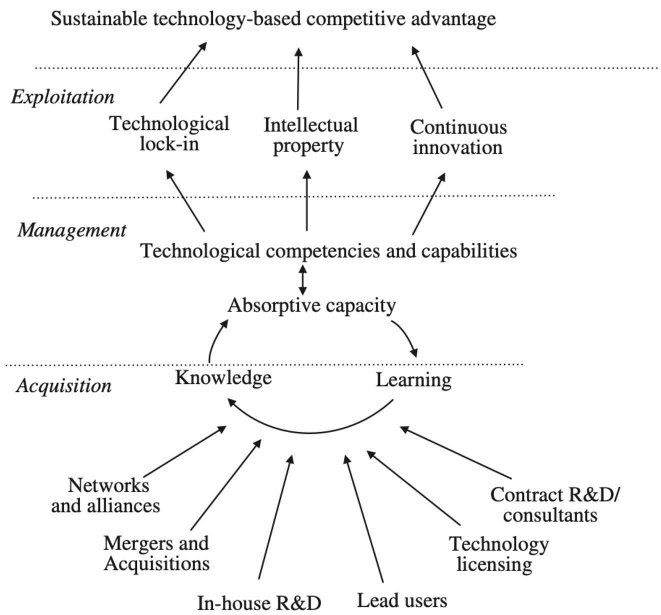

Figure 15 - The technology strategy model
(Davenport, Campbell-Hunt & Solomon, 2003)

Vintage Plough Back

The first loop of technology acquisition is described as the ‘*vintage plough back’* which describes a company's progression through multiple 'vintages' of technology and products, marking stages of exploration, learning, and innovation. It describes several ways of going through the vintage plough back. First of all, firms might develop products that meet local demand, establishing themselves within the market. While these products may not be groundbreaking, they generate cash flow, enabling the firm to experiment with new ideas and technologies and thus leading to a second phase. This experimental phase, considered a playful exploration, often involves low-risk applications of new technologies, leading to the creation of innovative products. Companies utilise various sources like lead users, licensing, and internal R&D to enhance their technological competence(s). These successive vintages form reinforcing cycles of technology development, continually building the firm's knowledge base and capacity for innovation. Cash flow from successful products fuels further innovation, enabling the firm to reinvest in the next vintage of products. Moreover, successful products necessitate increased production capacity, leading to mastery of production technology and market expansion. Each vintage provides opportunities to learn about consumer needs, refine technology, and improve organisational processes, creating a loop of continuous improvement. Repeated cycles through vintages also yield differentiation advantages, with the quality of learning determining the strength of the positive feedback loop. Key factors influencing this loop include capital, market knowledge, technology, production capacity, and scalability. (Davenport, Campbell-Hunt & Solomon, 2003)

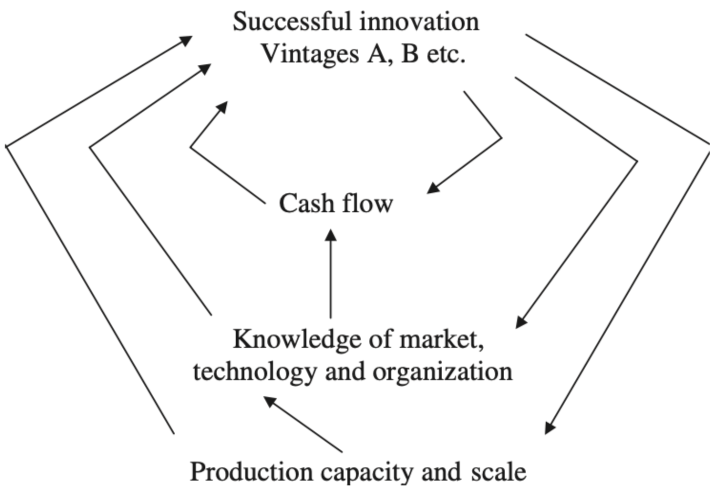

Figure 16 - Model of vintage plough back
(Davenport, Campbell-Hunt & Solomon, 2003)

Market Segment Leverage

The second loop is the '*market segment leverage*' that discusses how successive vintages of product innovation in firms proceed into parallel successive entries to new markets and market segments. Market Segment Leverage represents a strategic approach adopted by companies across industries, showcasing their progression through successive vintages of product innovation while expanding into new markets and diversifying their market segments. At its core, Market Segment Leverage involves leveraging insights and expertise gained from one market segment to penetrate and excel in subsequent segments. Companies embark on this journey by initially customising their products to cater to local market demands, often establishing a foothold within their industry. Despite these initial products not always being groundbreaking, they generate crucial cash flow, enabling companies to explore new ideas and technologies—a pivotal transition to the subsequent phase. This exploratory phase is characterised by low-risk applications of innovative technologies, leading to the development of truly innovative products. Companies harness various sources such as lead user insights, licensing agreements, and internal R&D to bolster their technological competence in a broad array of fields. These successive vintages create reinforcing cycles of technology development, progressively enriching the firm's knowledge base and capacity for innovation. The success of initial products fuels further innovation, enabling companies to reinvest in subsequent product vintages. This success also demands an expansion of production capacity, resulting in a mastery of production technology and an expansion of market scope. Each successive vintage offers invaluable opportunities to gain insights into consumer needs, refine technologies, and enhance organisational processes, fostering a continuous loop of improvement. Across industries, this iterative process of leveraging insights from one market segment into another runs parallel to cycles of product learning and innovation across successive vintages. It becomes a strategic cornerstone for companies looking to expand their market footprint and gain a competitive edge. This approach is not exclusive to specific sectors; rather, it serves as a blueprint for companies aiming to traverse from local market traction to a broader, international reach. By capitalising on their accumulated expertise and customer insights, companies strategically manoeuvre through different market segments, paving the way for a diversified product portfolio and establishing distinct market positions. The underlying dynamics of Market Segment Leverage underscore its role in gradually differentiating firms from their counterparts. Even smaller variations in initial market choices, when amplified through repeated cycles of market specialisation, culminate in distinct differentiation over time. This strategic leveraging of market insights and technological capabilities from one segment to another represents a fundamental driver for companies seeking sustained growth and competitive advantage in an ever-evolving business landscape. (Davenport, Campbell-Hunt & Solomon, 2003)

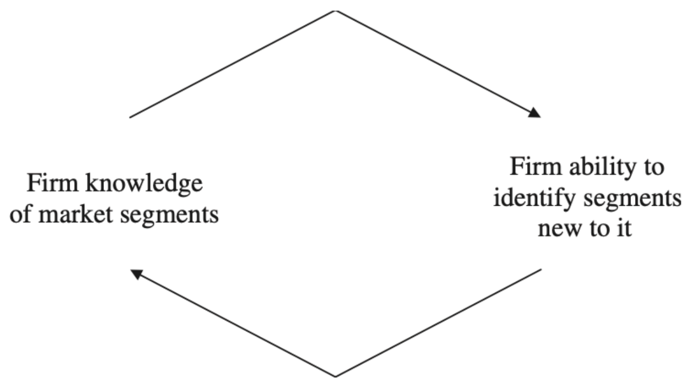

Figure 17 - Model for Market Segment Leverage (Davenport, Campbell-Hunt & Solomon, 2003)

Co-evolution With Lead Customers

The third feedback loop, termed '*co-evolution with lead customers*,' represents an alternative approach to technology acquisition, emphasising 'learning from each vintage.' This process hinges on pivotal customer feedback, compelling the company to refine its products or services in alignment with customer preferences. Adopting this method necessitates fostering a close relationship with customers, requiring the selection of the most valuable customers for learning purposes. Facilitating a lack of hierarchical structures then allows interactions across ranks, ensuring valuable insights from customers regardless of their status. Central to this approach is the ability to educate customers, aligning their needs with the company's offerings and fostering reciprocal learning. A crucial aspect involves the firm's engagement in educating customers about its products and, in some cases, extending this knowledge to the customers' own customers. This initiative not only cultivates robust, trusting relationships with distributors but also nurtures customer loyalty towards both the product and the company. (Davenport, Campbell-Hunt & Solomon, 2003)

The positive feedback loop facilitates a deeper comprehension of customer preferences while, in the meantime, increasing customer awareness of the product or service. The reciprocal relationship between the firm's technological advancement and its 'absorptive capacity'—the ability to identify the value of new information, assimilate it, and apply it for commercial purposes—coupled with the growing sophistication of customers, propels a process of coevolution between the company and its customers. This symbiotic relationship hopefully increases customer interactions and therefore acts as a source of innovation, moving beyond the exploration of technological opportunities to their strategic exploitation. (Davenport, Campbell-Hunt & Solomon, 2003)

To leverage this dynamic potential, firms must actively promote learning among their customers, mirroring their internal commitment to learning and innovation. This approach positions customer relationships as a perpetual source of innovative insights, enabling the firm to evolve its technological offerings in harmony with the evolving needs and expectations of its customer base. (Davenport, Campbell-Hunt & Solomon, 2003)

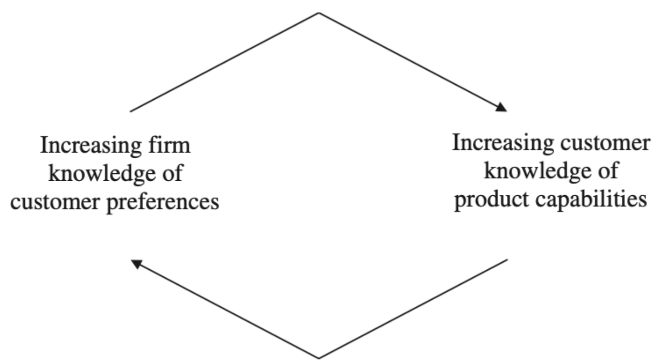

Figure 18 - The model over for Co-evolution with lead customers (Davenport, Campbell-Hunt & Solomon, 2003)

R&D Plough Back

The fourth loop, 'R&D plough back,' describes a method involving new investments within a company. This approach is commonly utilised and often serves as the primary source of new knowledge and innovation. Initially, R&D investments often start off modest, primarily being investments of time rather than finances. To bolster these efforts, firms often leverage government-sponsored technology initiatives to enhance both the quantity and quality of their research endeavours. Over successive decades, companies nurture their R&D capabilities, significantly enhancing their technical competencies and ability to acquire technologies. These capabilities form an invaluable repository of learning and knowledge, shaping a firm's operational ethos. (Davenport, Campbell-Hunt & Solomon, 2003)

To emphasise, the importance of R&D investment is essential for any high-tech firm. But then in order to retain these investments, patents, alongside investments into their technically skilled personnel, often play pivotal roles in capitalising on technologies. Especially, as product- or service technology complexities increase and production methods streamline, acquiring technical skills, whether through education or experiential learning, becomes imperative in the acquisition process. Firms using this approach typically exhibit a proactive stance in acknowledging and rectifying skill deficiencies, fostering environments centred on continuous learning and skills development. This focus on skills and learning often becomes an attractive proposition for potential recruits, drawing candidates to firms investing significantly in R&D. This skilled base may not always be entirely internalised but could also be accessed through specialist contractors, guiding the organisation's future trajectories. Companies excelling in proprietary technology often witness higher profit margins, allowing profits to be ploughed back into further R&D initiatives, amplifying the firm's technological prowess and establishing it as an innovation frontrunner. Then, as the company's technology reputation grows, it becomes a magnet for top-tier global R&D talent. Repetitive cycles of accumulating R&D staff and expertise contribute to the firm's differentiation over time. Choices in product innovation, staff recruitment, and the formation of R&D networks, all influenced by the firm's unique structure and culture, gradually solidified its position as an innovation leader. (Davenport, Campbell-Hunt & Solomon, 2003)

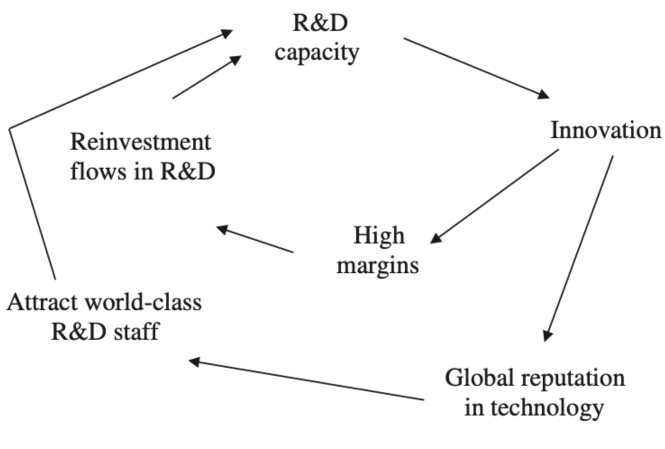

Figure 19 - The model for R&D Plough Back (Davenport, Campbell-Hunt & Solomon, 2003)

Co-evolution With Technology Partners

'*Partnerships*', or '*co-evolution with partners*', form a strategic cornerstone for firms seeking to bolster their technological capabilities. Over time, these alliances foster a more equitable exchange of knowledge among partners. By cultivating a spectrum of such alliances, firms integrate into expansive knowledge-sharing networks, often spanning the global landscape. These international networks serve as pivotal assets in maintaining regional or global leadership positions. They often evolve naturally from professional connections nurtured by specialised staff, culminating in networks of '*peer*' firms. For instance, knowledge-sharing alliances with technology associates transcend geographical boundaries, enabling companies worldwide to tap into such international peer networks. The number of partners and closeness of ties to these technology partnerships varies across firms, subject to positive feedback processes. Notably, these partnerships significantly enhance firms' technological knowledge and capabilities. (Davenport, Campbell-Hunt & Solomon, 2003)

As firms deepen their understanding of technology and its global sources, they expand their networks by collaborating with partners offering mutual technological advantages. Such partnerships facilitate specialisation, enabling firms to address capability gaps in their partners and further their own strengths. Initially unilateral dependencies often evolve into reciprocal relationships, benefiting both parties and strengthening their bond. These relationships evolve into mutually beneficial alliances, culminating in joint co-evolution and the collective advancement of technological prowess among member firms. Two distinct choices embedded in this loop contribute significantly to differentiating firms from their competitors. Firstly, the selection of partners is unique to each firm, influenced by its accumulated partner configurations. Secondly, the decision to specialise in particular technologies is intricately shaped by the firm's technological evolution and the distinctive capabilities present within its partnering network. These strategic choices, coupled with the evolving nature of partnerships, serve as pivotal drivers in enhancing firms' competitive advantage and shaping their technological trajectories. (Davenport, Campbell-Hunt & Solomon, 2003)

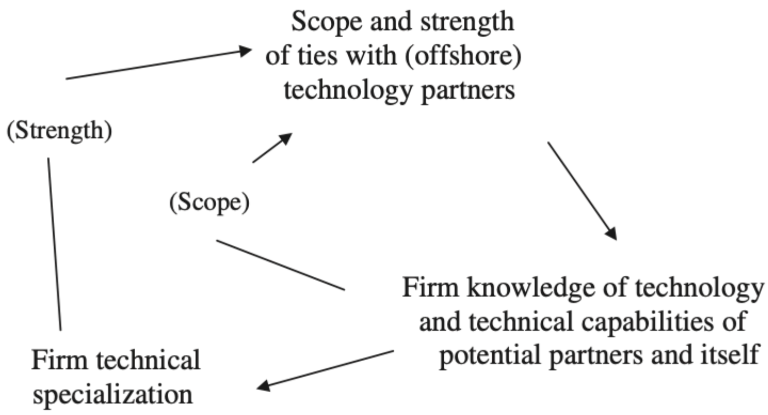

Figure 20 - The model for Co-evolution with technology partners (Davenport, Campbell-Hunt & Solomon, 2003)

Co-evolution With Suppliers:

While firms predominantly seek knowledge networks offshore, their growth significantly influences local capabilities. Many firms, therefore, actively engage local suppliers, leveraging existing traditions or capabilities, prompting these suppliers to enhance their performance to meet required standards in capacity and quality and sparking 'Co-evolution with their suppliers'. (Davenport, Campbell-Hunt & Solomon, 2003)

Some core firms intentionally guide and support suppliers to attain the necessary levels, fostering a symbiotic growth trajectory for both entities. This mutual co-evolution often sparks a clustering effect. Core firms typically initiate this effect by fostering the co-evolution of multiple suppliers, which subsequently influences their own supplier networks. As this ripple effect extends to related industries, such as educational suppliers, the emergence of smaller clusters becomes apparent. (Davenport, Campbell-Hunt & Solomon, 2003)

In certain instances, both firms and suppliers witness an elevation in sophistication, quality standards, and technical capabilities. The rising demands placed by firms spur suppliers to meet these requirements, subsequently alleviating constraints on firms for further advancements. (Davenport, Campbell-Hunt & Solomon, 2003)

Iterative cycles through these processes serve as a key differentiator for firms, fostering co-specialised assets between firms and their suppliers. This collaboration yields consistent expertise across successive stages of the value chain, driving both efficiency and innovation. This interconnected growth and development between firms and their suppliers not only elevates local capabilities but also delineates a unique trajectory for the firm. The nurturing of specialised assets and mutually beneficial relationships further solidifies the firm's competitive edge, setting it apart from competitors in the industry. (Davenport, Campbell-Hunt & Solomon, 2003)

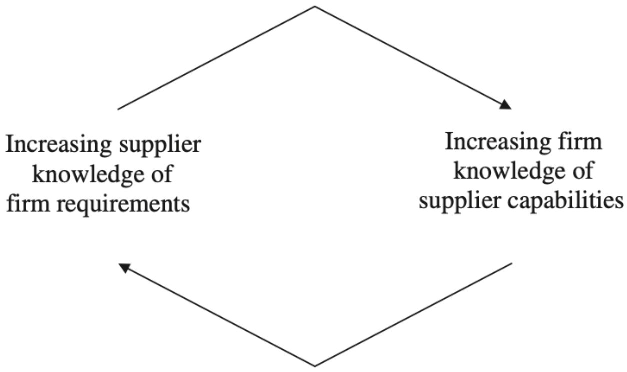

Figure 21 - The model for Co-evolution with suppliers (Davenport, Campbell-Hunt & Solomon, 2003)

International Focus And "Surviving The Gusher"

To round up the final part in the journey of a company's technological strategy, the pivotal phase often culminates in a transition to an 'international focus'. In order to do this the company needs to provide leading market shares across multiple geographic regions, actively operating in numerous countries where some have even established dominance in global niche markets, a testament to their technology-driven product innovations. This pivotal stage marks a clear shift in technology strategy, transitioning from exploration to exploitation. In order to do this, some firms intuitively sensed their products' potential beyond their home markets, while others required persuasion from international experts to recognise the broader value of their technology on a global scale. Discovering the market worth of their innovations elevated these firms' confidence, propelling them to take the leap into the global arena. Their distinction in international markets largely stems from their adeptness in differentiating their products from global competitors. Amidst this global expansion, firms meticulously assess functionalities that distinguish their offerings, catering to the precise needs of their target customers. Leveraging their expansive product and technological knowledge, these firms identify and nurture connections in technology and markets, insights often concealed from their more specialised counterparts. Through flexible production capabilities, they carve valuable niches by crafting highly customised products, fostering considerable loyalty among their international clientele. The experience of sudden international success has led to profound consequences for these firms. (Davenport, Campbell-Hunt & Solomon, 2003)

Most discovered the untapped international potential of products developed initially for their home markets. This realisation sparked a period of rapid growth, dubbed 'the gusher', driven by soaring demands in markets several times larger than their previous operations. However, the rapid influx of growth placed immense stress on these companies, leading to challenges in quality control, delivery, and staff training, threatening their credibility in newly entered markets. Nevertheless, the alternative, not seeing international opportunities, proved riskier for some firms. (Davenport, Campbell-Hunt & Solomon, 2003)

Another consequence of pioneering international markets with their products was the ability to influence and establish industry standards. Lobbying efforts were critical, 'locking in' new market niches to product specifications, fortifying the firms' positions and sometimes 'locking out' encroaching rivals. This strategic positioning allowed firms to capitalise on being first-to-market, establishing their systems as de facto world standards. (Davenport, Campbell-Hunt & Solomon, 2003)

The surge in demand for internationally successful products forced firms to focus resources and production capacity predominantly on these products. This 'focus and grow' approach led to the discontinuation of portfolios developed for domestic markets as firms raced to meet offshore demands. This intensified focus enhanced their capacity to expand into new offshore markets, perpetuating the cycle of demand growth. The strength of this 'focusing' loop varied among companies. In instances where products held strong appeal offshore, and firms chose to capitalise on this appeal, the loop proved potent, swiftly transforming companies into leading competitors across multiple international markets within tightly focused product niches. This transformation radically reshaped firms' product and market scopes within a few short years. For other firms, where offshore appeal was less compelling or where risks of rapid expansion were deemed unfavourable, the results were less dramatic. (Davenport, Campbell-Hunt & Solomon, 2003)

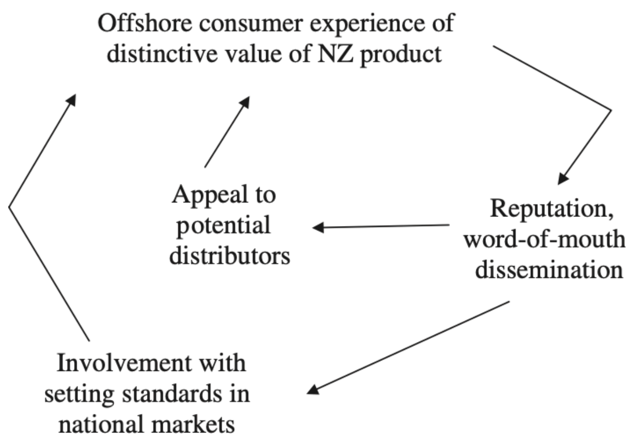

Figure 22 - Model of international focus "surviving the gusher" (Davenport, Campbell-Hunt & Solomon, 2003)

3.5.4 Evaluation of Technology Acquisition

Now with the different methods of technology acquisition introduced the question remains - which of these methods should be used in different scenarios? There have been multiple studies that have evaluated this and the conclusion is that it's often a combination of multiple methods that should be used in conjunction with each other (Davenport, Campbell-Hunt & Solomon, 2003; Ford, 1988). This is evident among other parts by the fact that they share the same aspects in the same model, for example, knowledge of markets appears in several loops, so these should be seen as multiple positive reinforcements that have produced transformations in the strategic capabilities. (Davenport, Campbell-Hunt & Solomon, 2003). Another part that this shows is that the different processes are involved in repeated cycles which cycles mutually reinforcing behaviour. This will in turn lead to what is learned in one cycle might be applied to guide the choices in the next. Each cycle is thus both an exploration of what is possible and an exploration of what has been learned in previous cycles.

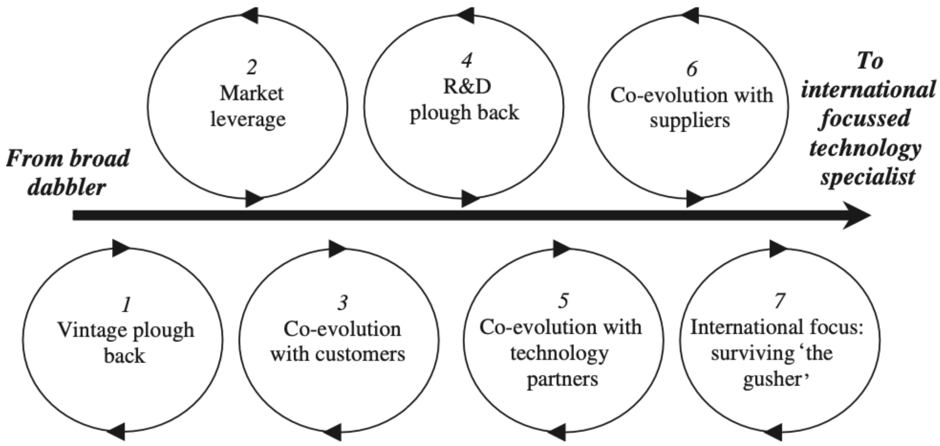

Figure 23 - The revolving evolution of the 7 described models for technology acquisition (Davenport, Campbell-Hunt & Solomon, 2003).

However, if you're uncertain about which method to pursue for technology acquisition, Ford's (1988) proposed guidelines can assist in decision-making. Before starting though, a comprehensive technology strategy formulation is crucial, encompassing strategy development, objective statements, and assessments, addressing Ford's prescribed questions at the start of section 3.4. After this, several factors play a pivotal role in determining the most suitable acquisition strategy. Most importantly the company's relative standing with the technology, the urgency to acquire the technology, what the commitment/investment cost would be involved with the acquisition, where the technology is in its life cycle, and what type of technology it would be characterised as. Figure 24 provides an informative overview of how the different aspects impact what type of acquisition method should be used.

Acquisition Methods	(1) Company's Relative Standing	(2) Urgency of Acquisition	(3) Commitment/ Investment Involved in Acquisition	(4) Technology Life Cycle Position	(5) Categories of Technology
Internal R&D	High	Lowest	Highest	Earliest	Most Distinctive or 'Critical'
Joint Venture		Lower		Early	Distinctive or Basic
Contracted-out R&D		Low		Early	Distinctive or Basic
License-in		High	Lowest	Later	Distinctive or Basic
Non-acquisition i.e. Buying Final Product or Part Production From Others	Low	High	No Commitment/ Investment	All Stages	External

Figure 24 - Factor affecting the technology acquisition (Ford, 1988)

3.6 Scenario Planning

3.6.1 What is Scenario Planning and Why use it?

Scenario planning is a planning tool to deal with uncertainty in the future. Scenario planning consists of two phases, '*scenario analysis*' and '*strategic planning*', which are linked together by the scenarios created during the analysis phase. Another way to put it is that scenario planning is the combination of *scenario analysis* for strategic purposes and *strategic planning* based on the result of the scenario analysis.

The purpose of scenario planning is to provide a higher level of future analysis when there are several uncertainty-based futures. By doing so an organisation may increase its response ability and robustness for future challenges. The main purpose of scenario analysis is therefore not to predict the future; it is to create awareness of possible futures. It is also a way to learn more about the business environment and its trends, driving forces, uncertainties, risks and possibilities to avoid making wrong decisions. This report uses the first phase of strategic planning, that is, scenario analysis, and its methods to fulfil the purpose of the study. In order to do this, the methods will be described in the theory (part 3.5). (Bandholm & Lindgren, 2009)

Scenario planning is also a way of interpreting what the outcomes of the future might be. To make this a multitude of possible future scenarios are interpreted to come up with the answer to the questions (Bandholm & Lindgren, 2009):

- ➢ What are the desired outcomes?
- ➢ What are the likely outcomes?
- ➢ What are the possible outcomes?

To make this several different paths to these outcomes are also interpreted to classify what the road there will be. The major benefits of making different scenarios are as: (Bandholdm & Lindgren, 2009)

- ➢ It's a format that is suitable for the brain - As the development and procurement of the scenarios work much in the same way as a brain interprets data it makes scenarios that are easy to remember and thus you can bring the possible to life.
- ➢ It creates possibilities to see opportunities and think differently - Through the usage of forcing qualitative thinking, scenario planning provides different directions of working our ability to see the unthinkable. The open format, where nothing is right or wrong also contributes to a combined exploration of the future
- ➢ It's a format that reduces the complexity - Through different scenarios, a complex world can be summed up to a workable uncertainty. The scenarios here make it easier to reduce complexity without risking oversimplification
- ➢ It's a communicative format - It's easy to communicate scenarios to others and then discuss them. Therefore the format will be suitable to propose further propositions and create a common exploration that simplifies the decisions of the future.

3.6.2 What Makes a Good Scenario?

To create a good scenario Lindholm and Bandholm (2009) have proposed that seven criteria must be satisfied, them being:

- ➢ Decision-making power - Each scenario has to give insights into what it is that will satisfy the question that is being asked, and what amount of impact the decisions will have on it.
- ➢ Possibility - The scenario needs to be realistically possible.
- ➢ Feasibility - Each scenario alternative should, at least in some regard be feasible and correspond somewhat with each other with the probability of them happening.
- ➢ Consistent - Each scenario has to have an internal as well as external consistency to provide logic and increase the credibility of the scenarios.
- ➢ Differentiated - Each scenario should be different enough in terms of structure and character. It's not enough to just make different variations of an original scenario.
- ➢ Rememberable - The scenarios should be easy to remember and distinguish from each other. Therefore to just decide a smaller number of three to five scenarios should be used, rather than six or more.
- ➢ Challenging - The last criterion is that the scenarios are a challenge for the organisation and that will create a difference towards the future

3.6.3 Models for Scenarios

When deciding what scenarios should be used, this thesis uses the expert model, which is characterised by the work that is made by the planner (thesis students) alone. The planner is thereby him- or herself controlling the process, and the results are presented by the planner and the planner is solely responsible for the completion of the task. (Bandholm & Lindgren, 2009)

In order to create high-quality scenarios the TAIDA model will be used. TAIDA is a well-proven planning tool that presents five steps: tracking, analysing, imaging, deciding and acting to aid in the scenario planning process. (Bandholm & Lindgren, 2009) A quick summary of each step is provided below and a more detailed summary is provided in 3.4.4

- ➢ Tracking: This part deals with interpreting challenges and possibilities to track down and describe changes and describe why the scenarios should be developed in the first place. This part has already been introduced in the first Chapter of the thesis.
- ➢ Analysing: The next step is to analyse the changes and from those develop different scenarios that can further the knowledge base of the company. This will be done in Chapter 6.3
- ➢ Imaging: After the scenarios have been created this step deals with the identification of possibilities and presents what future is possible
- ➢ Deciding: This step is about identifying development areas and interpreting the information from the scenarios so that future goals can be set up
- ➢ Acting: The last step acts as part of decking on short-term goals to take the first steps towards the desired outcome.

3.6.4 Implementation of the TAIDA model

To use the TAIDA model a short introduction of the prerequisites, and the five different parts of the TAIDA model will be presented:

Prerequisites

In order to use the TAIDA models some tasks and requirements first need to be solved. Firstly, there is a need to identify the system that will be analysed. This can take many shapes but the requisite here is primarily that the planner of the scenarios needs to be sufficiently familiar with the task in order to understand what challenges might occur and what problems need to be solved. After this, a time horizon needs to be presented. This doesn't need to be exactly precise, but there are large differences when setting a 2-year or a 20-year plan, thus somewhat of an understanding is needed. The next step is defining the past and the present, as this presents a starting point from which the scenarios originate. In this thesis, this point was the start of the thesis (16th October 2023). Now that the problems have been formulated and the starting point has been established, an analysis of the current situation has to be done, in order to get an overall perspective of the underlying conditions. (Bandholm & Lindgren, 2009)

T - Tracking

With a clear purpose, a clear framing of the question, a time horizon and a good map of the past and the present it's time to start tackling the future. This part mainly consists of tracking new changes and trends in the environment that can impact the framing of the question. Tracking deals with finding these trends, driving forces and uncertainties that might impact the future of the question. This is therefore usually done by performing an outside-in-analysis of the company. In this thesis, no analysis of trends will be done, as the authors will only rely on the work presented by earlier authors, and for the case company, the trends posed on the company itself will be used. (Bandholm & Lindgren, 2009)

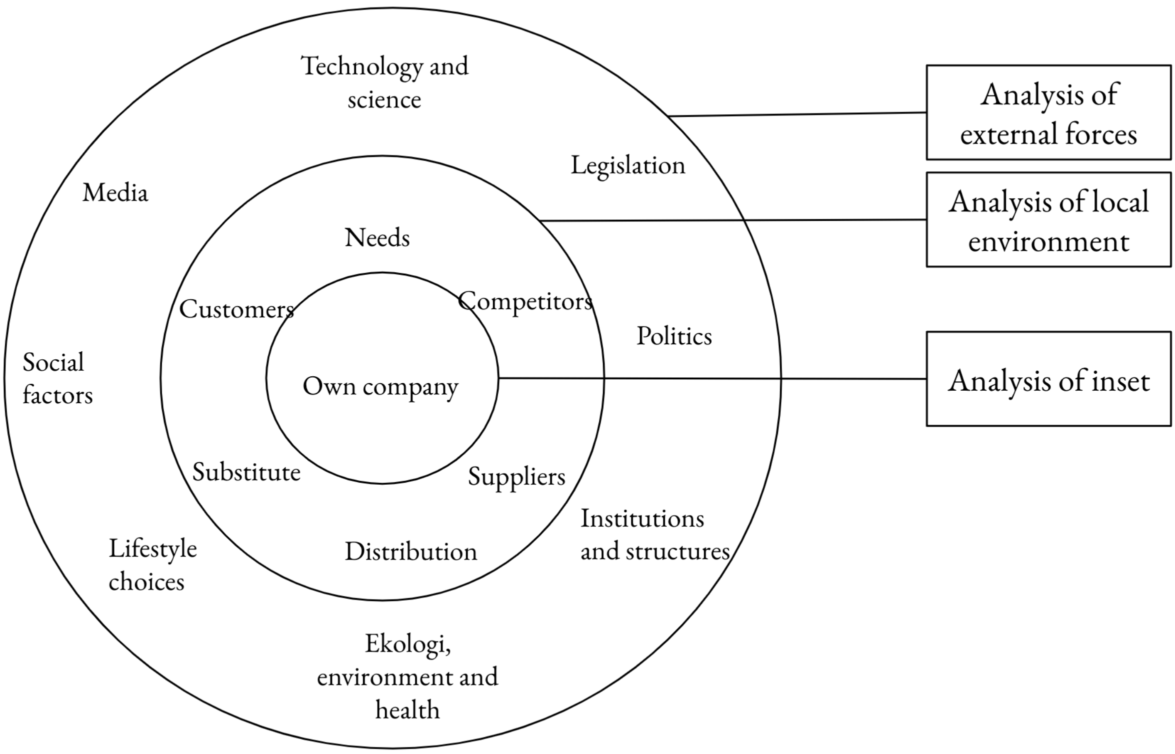

Figure 25 - Outside-in perspective in scenario planning (*Bandholm & Lindgren, 2009*)

A - Analysing

When the tracking phase has ended, there are often several separate trends that span a multitude of areas presented. But trends are often not as different from each other as they first seem. When observing and describing one can often find that certain trends come from the same driving force or as consequences from some earlier trend. The patterns are what this part mainly needs to decipher to find out what driving forces and consequences will have an impact on the following steps. In order to create this understanding one needs to delve deeper into the system and perform some kind of analysis of what scenarios might occur. There needs to be a baseline “safe” trend to act as the background and let your scenarios play out in front of these safe trends, from which one can analyse and gain greater insights. The qualitative reasoning is what's important here. From this, one will be able to create timelines which act as probable developments. This might be done with several aspects when the different scenarios are unknown, for example, by a Cross-impact analysis. (Bandholm & Lindgren, 2009)

I - Imaging, D - Deciding, A - Acting

The following parts all deal with a different aspect of implementing the desired scenario so that one might have a correct implementation of the scenarios. Since this thesis does not consider the correct implementation of the scenarios, these Chapters won’t be presented any further than in the summary.

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4. **Prestudy**, Introduction of Case Company

This chapter contains a pre-study of the studied company Flower Infrastructure Technologies AB, the market that they operate in, as well as, the development of BESS technologies. All aspects which are needed in order to understand the empiricism and analysis for the following chapters will be displayed.

4.1 Introduction

To provide an understanding of the case company an introduction of it is required. This Chapter aims to provide essential knowledge for the reader to understand what Flower Infrastructure Technologies AB is and what sphere it operates in. It will give ample information on how the company creates value, how the company is structured, what products and services it provides, what the revenue model of the company is as well as what the general market around the company looks like.

Also, to understand the need for a BESS an introduction to the development of clean energy systems is provided in the second part of the prestudy. Appendix C is also provided to showcase more sufficient information about a BESS if the reader is interested. This might also make it easier for the reader to understand what a BESS is as well as why it's needed. This part will show how the landscape of companies operating today has changed and in what ways the development of the power grid will have an impact on markets in the future. Lastly, this chapter will narrow down to provide the necessary information on the Swedish markets which will later be used in this thesis.

4.2 Case Company Profile

4.2.1 Introduction of Flower Technologies

Flower Infrastructure Technologies AB (hereinafter referred to as Flower or Flower Technologies) is a company operating in the Power Refinery market. The company specialises in developing software related to energy, specialising in designing and constructing energy infrastructure essential for the energy transition, with the aim of reducing society's dependence on fossil fuels. More precisely, Flower defines its mission as (Flower Infrastructure Technologies AB, 2023a):

"Drastically increasing the available power flexibility to support the renewable electrification of everything."

To achieve this mission, Flower Technologies optimises the activation behaviour and trading strategies of different renewable energy assets to support the grid via energy markets. Its assets include large-scale facilities such as battery parks, solar power parks, and industrial installations, as well as small-scale facilities like electric vehicle chargers and home batteries. The case company's operations are coordinated from its local office in Stockholm, covering a broad geographical scope that includes Sweden, Denmark, the Netherlands, Belgium, France, Germany, and Austria. (Flower Infrastructure Technologies AB, 2023a)

4.2.2 Flower's Story

The company was initially established in 2020 under the name Krafthem. However, in 2022, it underwent a significant rebranding, adopting the name Flower. This name change sets the stage for the case company's global expansion ambitions and underscores its commitment to serving business-to-business (B2B) markets. The name "Flower" not only symbolises the intricate and delicate nature of the electrical systems but also cleverly plays with the concept of "flexible power" (My news desk, 2022a).

Flower was founded by John Diklev, who continues to serve as the CEO and holds a significant ownership stake of 37.6% in the company. Other major stakeholders, each holding more than 10% of the company, include 41an Invest AB with a 21.89% stake and Quiq Holding AB with a 17.19% stake (Flower Infrastructure Technologies AB, 2023a). In 2022, Ellevio, one of Sweden's largest energy companies, and Flower initiated a significant strategic collaboration to accelerate the commercialisation of innovative solutions. In connection with the partnership, Ellevio invested in Flower, acquiring a 10% stake (My News Desk, 2022b).

Flower Technologies has been experiencing exponential growth, with its revenue increasing from 3 753 SEK in 2020 to 1 078 846 SEK in 2021, and further to 4 972 052 SEK in 2022 (Flower Infrastructure Technologies AB, 2023a).

Amount in SEK

Table 3 - Development of the case company's operations, results, and position

Variable	2022-12-31	2021-12-31	2020-12-31
Net sales	4 970 252	1 078 846	3 753
Operating margin %		Neg.	Neg.
Balance sheet	83 884 691	5 758 046	4 778 448
Return on capital employed %	Neg.	Neg.	Neg.
Return on equity %	Neg.	Neg.	Neg.
Solidity %	93,4	84,9	89,5

4.2.3 Organisation Structure

Flower has a flat hierarchy structure and is characterised by trust and transparency - internally and externally. The person closest to the problem can always step in and handle the situation, instead of waiting for the leadership to make a decision (Interviewee 6, 2023). Furthermore, the company is split into several different branches dealing with different aspects of the company, them being, crude sourcing, exploration and production, operations, power refinery, strategy and corporate. A short description of these different parts as well as their operation area is summarised in Table 4 below: (Flower Infrastructure Technologies AB, n.d.a; Flower Infrastructure Technologies AB, n.d.b; Flower Infrastructure Technologies AB, n.d.c; Flower Infrastructure Technologies AB, n.d.d; Flower Infrastructure Technologies AB, n.d.e; Flower Infrastructure Technologies AB, n.d.f)

Table 4 - Brief description of the different branches of Flower

Branch	Summary of the Branch
Crude Sourcing	Crude Sourcing's mission is to identify assets with the potential to offer flexibility in the energy system. These assets can support the grid and connect to their platform for further refinement. Crude Sourcing operates through various squads, including sales, project management, and product development.
Exploration and Production	The exploration and production branch focuses on developing Battery Energy Storage Systems to aid the grid and facilitate the shift to renewable energy sources. They engage in co-investment, joint projects, and project sales, with a consistent role in asset optimisation.
Operations	The operations branch collaborates with cross-functional teams in all domains to provide essential resources for Flower's mission. Their focus on innovation and shared responsibility encourages forward-thinking initiatives that enhance the growth and success of the green tech company.
Power Refinery	At Power Refinery, the primary aim is to enhance the efficiency and impact of each energy asset. This is achieved by employing statistical methods, machine learning (ML), and optimisation algorithms. This process is focused on unlocking the latent potential within each asset, known as "flexibility." This flexibility enables the assets to actively contribute to maintaining a balanced and reliable power grid.
Strategy	The Strategy Office monitors the future landscape to drive the green energy transition. Their role includes exploring new business prospects, expanding into different markets, and ensuring Flower's position as a leading tech company in the energy sector. They also lead strategic initiatives, analyse markets, and collaborate with industry experts to pave the way for the commercialisation of fresh value streams.
Corporate	The corporate branch of Flower deals with the strategic choices of the company. This branch consists of the board (CEO, CFO, COO) as well as marketing director, SCO, Talent acquisition manager and Talent acquisition specialist.

4.2.4 Products and Services

Flower operates a Virtual Power Plant (VPP), which is a cloud-based platform that connects and manages a diverse range of energy assets, such as solar panels, wind turbines, batteries, and other decentralised power sources. In essence, a VPP enables the aggregated control and optimisation of these distributed resources to function as a unified and flexible power generation system. It allows for the efficient and responsive management of energy supply and demand in real time by participating in energy markets. This contributes to grid stability and supports the integration of renewable energy sources. What makes Flower stand out from others is their Multi-Market Optimisation Model (MMO), an advanced trading algorithm (see Figure 26 below). The algorithm uses Machine learning (ML) to allocate available capacity in the markets by making price predictions for services in markets like Upward/Downward Frequency Containment Reserve - Disturbance (FCR-D), Frequency Containment Reserve - Normal (FCR-N), Automatic Frequency Restoration Reserve (aFRR), Fast Frequency Reserve (FFR), Manual Frequency Restoration Reserve (mFRR) and Nord Pool Spot. Furthermore, it combines these predictions with machine-learned capacity forecasts to predict the power grid's output accurately. Having provided ancillary services to Svenska kraftnät since June 2021, they have acquired valuable insights into the current design of TSO markets and their potential future developments. (Flower Infrastructure Technologies AB, 2022a)

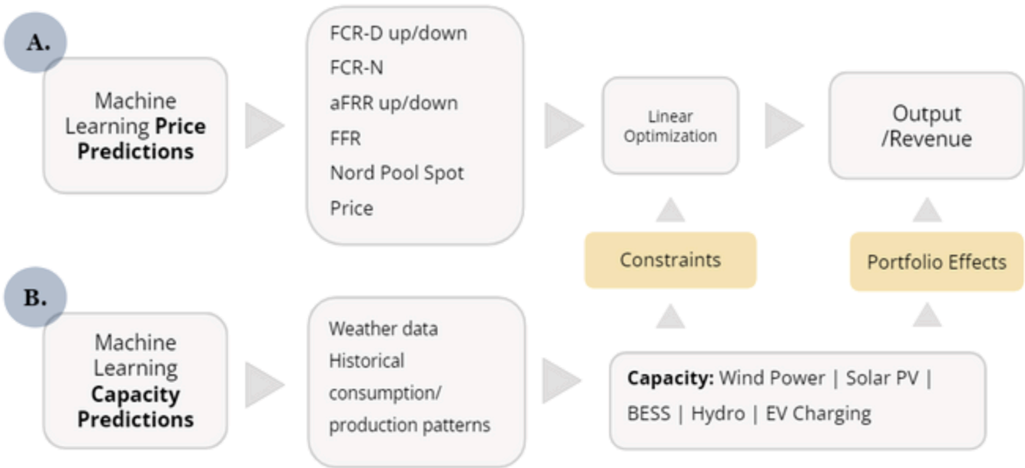

Figure 26 - Illustration of the Chain of Value Creation through Flower's optimisation of assets in a diversified power portfolio Flower Infrastructure Technologies AB. (2022a)

While the majority of assets are owned by corporate clients (B2B), Flower also provides services to individual customers (B2C) through its so-called Flower Hub. The principle, however, remains the same: homeowners with some form of electricity production and battery storage system can connect to the Flower Hub to support the electricity grid, generating revenue for the battery owner. (Flowerhub, 2023; Maricruz Bravo, 2023)

4.2.5 Revenue Model

With their advanced technology and expertise, Flower generates multiple sources of revenue. The focus is on offering frequency regulation services to system operators like Svenska kraftnät, and actively participating in intraday markets (Interviewee 3, 2023; Interviewee 6, 2023). This model capitalises on the inherent flexibility of partners' assets, strategically managed and modelled for utilisation in support service markets, currently with a lot of focus on the FCR market. While the wholesale sector presents heightened complexity, the current revenue generation primarily stems from ancillary markets. Looking ahead, there's potential expansion into wholesale markets, recognizing their evolving dynamics. Moreover, there's a forward-thinking approach, already exploring innovative revenue streams beyond FCR-D, acknowledging the eventual saturation of existing markets (Interviewee 7, 2024).

4.2.6 Markets and Stakeholders

4.2.6.1 Markets:

Flower engages in trading across various markets, including the Nord Pool Spot Price market, intraday and day-ahead markets, and ancillary services markets, encompassing FCR-D, FCR-N, aFFR, and FFR.

4.2.6.2 Customers to Flower

Flower has a diverse range of customers, primarily including grid operators such as regional operators and Svenska kraftnät, the Swedish TSO. Among its services, Flower delivers FCR to Svenska kraftnät, playing a crucial role in sustaining a stable grid frequency. Investors form another significant customer segment, acquiring Flower's assets, for instance, batteries and engaging in revenue-sharing arrangements. Additionally, companies owning substantial assets like solar and wind parks, as well as batteries linked to Flower's VPP, are part of the customer base. These batteries, including those supplied by Flower, contribute to grid flexibility. Residential individuals with batteries connected to the Flower Hub also play a role, offering grid flexibility and generating revenue for the battery owners.

4.2.6.3 Competitors

Flower faces a competitive landscape with a diverse array of competitors spanning both national and European markets. In Sweden, competitors include Fortum, Vattenfall, CheckWatt, Fever, Tvinn, Varberg Energi, NGENIC, Sympower, Checkbot, Fiber, Ox2, Stockholm Exergi, Primrock, Enfo, and Nitricity (Interviewee 5, 2023). Each of these entities contributes to the vibrant and evolving energy sector within the country.

On a broader European scale, Flower contends with competitors such as Next Kraftwerke, Poluens, Polarium, Kraken, Wärtsila, Arenko, Limejump, Enova, Yuso, Powerhouse, Habitat Energy, Grid Beyond, Greener, Energy Pool, Semper Power, Fortum, Vattenfall, GIGA Storage, Flexcity, Sholt Energy, and Flexitricity. This diverse set of competitors reflects the dynamic nature of the European energy market, where companies engage in innovative solutions and services, striving to meet the evolving needs of the industry and its stakeholders.

Compared to their competitors Flower secures a commanding position in the market by actively engaging in the construction of battery parks and integrating diverse resources for modulation, optimisation, and control. In contrast to certain competitors who may be deficient in one or more of these critical aspects, Flower distinguishes themselves as an industry leader and maintains awareness regarding its competitors' activities. Their belief is grounded in the conviction that they're developing a unique, optimal solution that is more valuable than merely following the strategies of competitors. This has thus far been working for that, for example, in Sweden they are the majority supplier in the ancillary services market.

4.2.6.4 Partners, investors and stakeholders

Flower currently boasts numerous strategic partnerships. One interviewee said that they have 8-9 partners with whom they are involved today and that in some of these projects, there might be as many as 3-4 stakeholders involved (Interviewee 5, 2023). The relationships are also considered to be positive. All the interviewees considered the bond with the suppliers and partners as positive, although some believed that the relationship could get better. "Our relationship varies from fantastic to okay. With larger partners such as Ellevio, our relationship is great. On the other hand, smaller partners have too high expectations and there can be difficulties in meeting their wishes from our side" (Interviewee 5, 2023). None of the other interviewees had anything bad to say about their partners although, according to one interview, none of these deal with technology development (Interviewee 3, 2023). There are also several financial stakeholders involved with Flower, some of the larger ones being: (Flower Infrastructure Technologies AB, 2023a; My News Desk, 2022d)

- 41an Invest
- Ellevio Energy solutions
- Quik Holding AB

4.3 Development of Clean Energy Economy and Technologies

4.3.1 Global Clean Energy Landscape

As a consequence of the energy crisis, the global energy landscape is undergoing a profound transformation, a green transition (as discussed in Chapter 1.1). In other words, this has brought up the emergence of a new clean energy economy - an economic system that prioritises energy sources that have minimal impact on the environment. In recent years, this transition has been accelerated by various factors: the response to the Covid-19 pandemic, the war in Ukraine, government initiatives and an increase in commercial and geopolitical competition. This acceleration can be seen in Figure 27 below, which shows a clear increase in global green energy investments since before the pandemic. Simultaneously, there is a rapid electrification ongoing in order to contribute to the clean energy economy. Industries are striving to meet the increased demand for sustainably produced and climate-friendly products, which means higher production of electricity-intensive products like fossil-free steel, electrofuels and batteries. Consequently, all of this leads to a substantial rise in electricity consumption, which is shown in Figure 28. (Energimyndigheten, 2023a; IEA, 2023a)

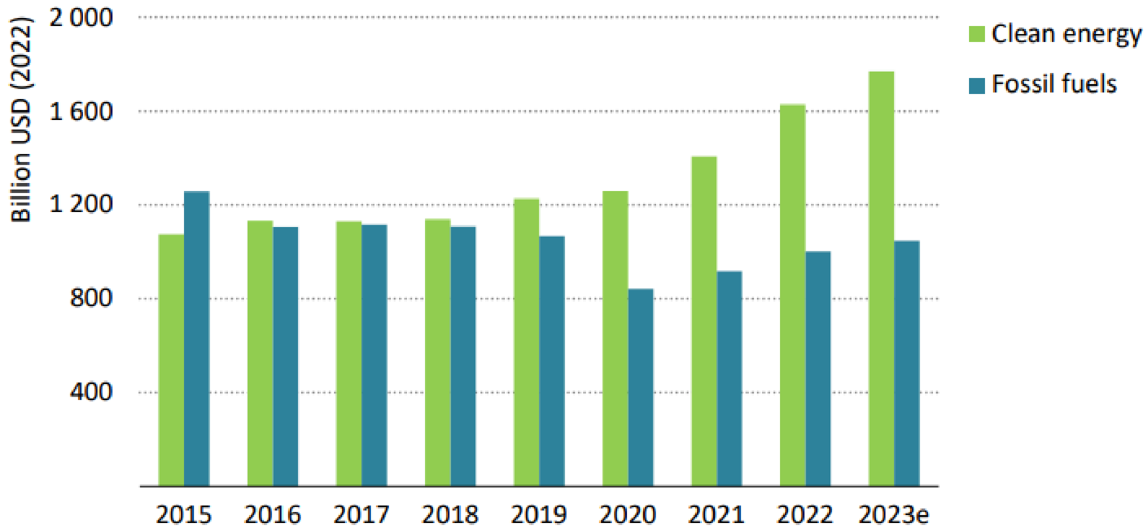

Figure 27 - Global energy investment in clean energy and fossil fuels. The investments for 2023 are estimated numbers. (IEA, 2023a)

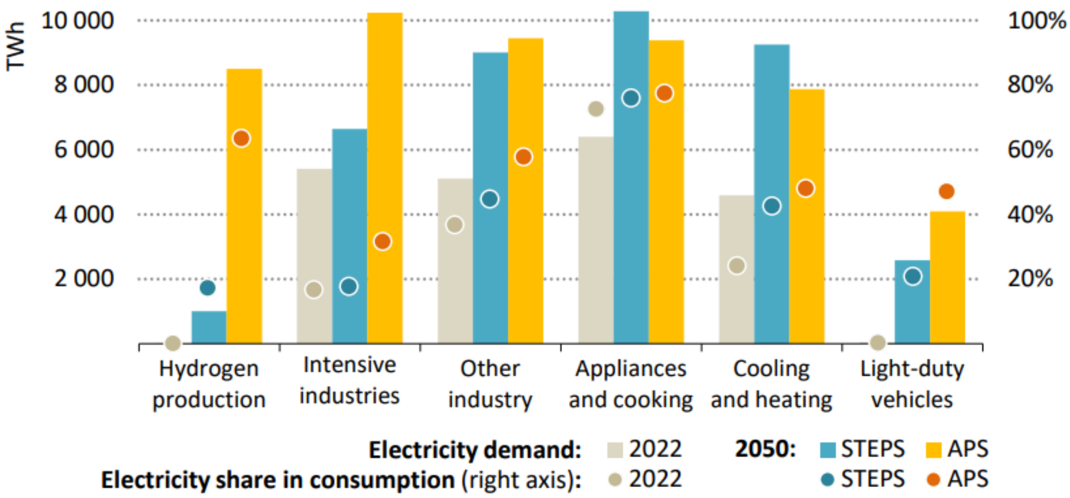

Figure 28 - Global electricity demand and share of electricity in selected applications in 2022 versus 2050. (IEA, 2023a)

4.3.2 Electricity Security

With the rising electricity demand, ensuring electricity security is a vital part of enabling the electrification of societies. The definition of electricity security is, maintaining a dependable and stable supply of electricity, that is capable of meeting demand at all times at an affordable price. However, this is not a new concept. The electricity supply has always been required to continuously meet the demand, down to the fractions of a second. This has however become more challenging as more and more renewable energy sources, such as variable wind and solar photovoltaics (PV), are integrated into the power grids - leading to a higher uncertainty in power generation. As a result of this, power system flexibility needs are projected to drastically increase in the future. In order to meet these needs, consumers should be more connected, power generators must enhance agility, and grid infrastructure needs digitalization for dynamic electricity and information flows. As can be seen in Figure 27, the largest drivers for the increase in flexibility needs are demand and solar PV. The supply for this increased demand will, by 2050, largely be met by demand response and batteries. Demand response opportunities are created from the expanding use of electric heat pumps, air conditioners and EVs, which all make demand more variable. In order to take full advantage of these opportunities, there is a need for a supportive regulatory environment that is based on suitable price signals, digital tools and smart controls. Batteries amount to the other largest supply of flexibility needs in the future. In the "World Energy Outlook 2023" report by the IEA, the lowest projection for utility-scale battery storage capacity, among three different future scenarios, is 85 times greater by 2050, amounting to over 2 TW. (IEA, 2023a)

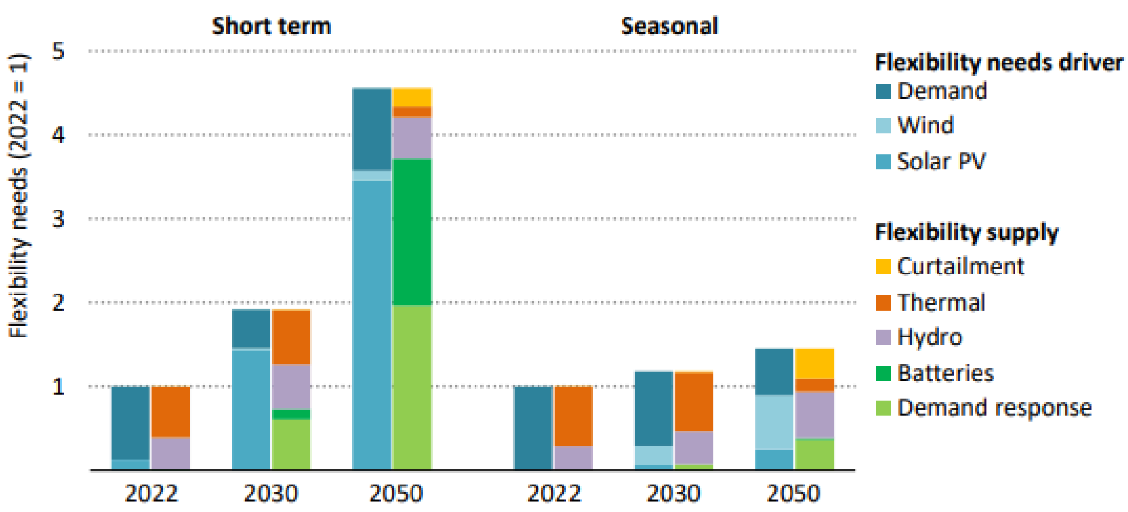

Figure 29 - Global power system flexibility needs and supply, according to the APS scenario. (IEA, 2023a)

4.3.3 Development Rate and Bottlenecks of Clean Energy Technologies

There needs to be improvements in clean energy technologies and their supply chains to meet all future projections. Since 2015 there has been significant progress in the development of clean energy technology supply chains. Especially those regarding manufacturing for solar panels and batteries, where facilities are capitalising on standardisation and shorter lead times. As manufacturing costs decrease, the price for various clean energy technologies decreases as well, which is shown in Figure 30 below. But there is yet much that has to be done. According to the IEA Tracking Clean Energy Progress (2023c), out of 50 technologies, only three were evaluated as being on track. These three are solar PVs, EVs and efficient lightning. The technologies that need further development to get fully on track are wind power, grids and storage, efficiency, innovation and digitalisation. As mentioned earlier, electrification technologies play a crucial role in the emerging clean energy economy, thus making developments in these technologies one of the focal points. Figure 31 below shows the risks linked with different clean electrification technologies. Each risk threatens the development of the respective technology. These technologies are not independent, meaning that progress in one technology may rely on advancements in another. Thus, to optimise a secure and affordable transition, it's important to lower the risk across the board. (IEA, 2023a)

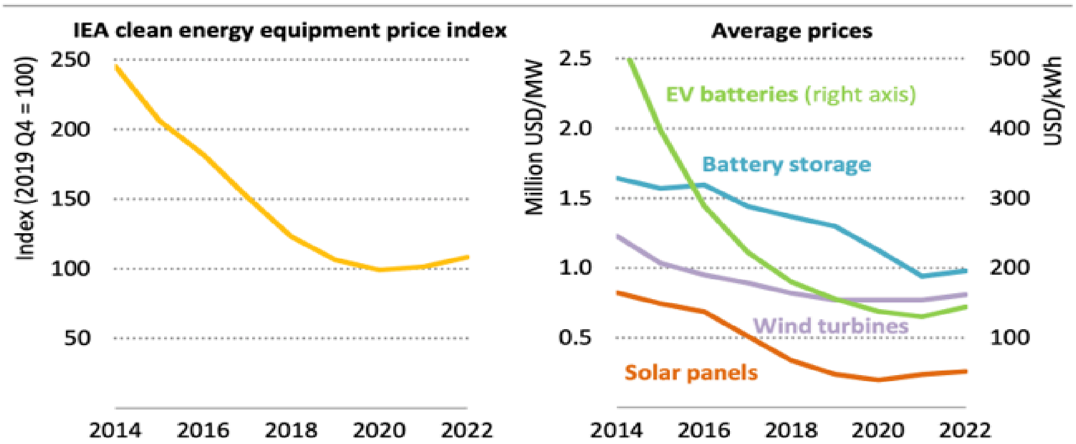

Figure 30 - Recent cost developments for selected clean energy technologies. (IEA, 2023a)

	Wind	Solar PV	Nuclear	Battery storage	Demand response	Grids	Electric vehicles	Heat pumps
Regulatory and policy risks								
Regulatory frameworks	Medium	Low	Medium	Medium	High	Medium	Medium	Medium
Policy support	Low	Low	Medium	Low	High	Low	Low	Low
Permitting and certification	Medium	Medium	High	Low	Low	High	Medium	Low
Supply chain risks								
Critical minerals	High	Medium	Low	High	Low	Medium	High	Low
Manufacturing	High	Low	Medium	Medium	Low	Low	Low	Medium
Skilled labour	Medium	Medium	High	Low	Low	High	Low	Medium
Financial risks								
Costs of financing	High	Medium	High	Medium	Low	High	Medium	Medium
Revenue and savings predictability	Medium	Low	Low	Medium	Medium	Low	Low	Low
Overall risks	High	Low	Medium	Medium	Medium	High	Low	Medium

Figure 31 - Primary risks associated with key clean electrification technologies. (IEA, 2023a)

4.3.3.1 Critical Minerals Used in Batteries

Regarding battery storage, the most significant risk is the availability and price of critical minerals (see right-hand side of Figure 29 above). The anticipated increase in critical mineral supplies does not align with advancements in manufacturing, particularly those in the production of batteries. In supply chains, the rate of transition is frequently dictated by the slowest-moving element, making critical minerals a bottleneck. Demand for critical minerals used in clean energy technology is projected to increase heavily, with the drivers being EVs and battery storage (see Figure 32 below). However, there are big concerns about meeting these demands. Figure 33 shows the recent price developments of these critical minerals. The price surges that occurred in 2022 have been mitigated, but the prices are still higher compared to the 2016-2020 averages (IEA, 2023a).

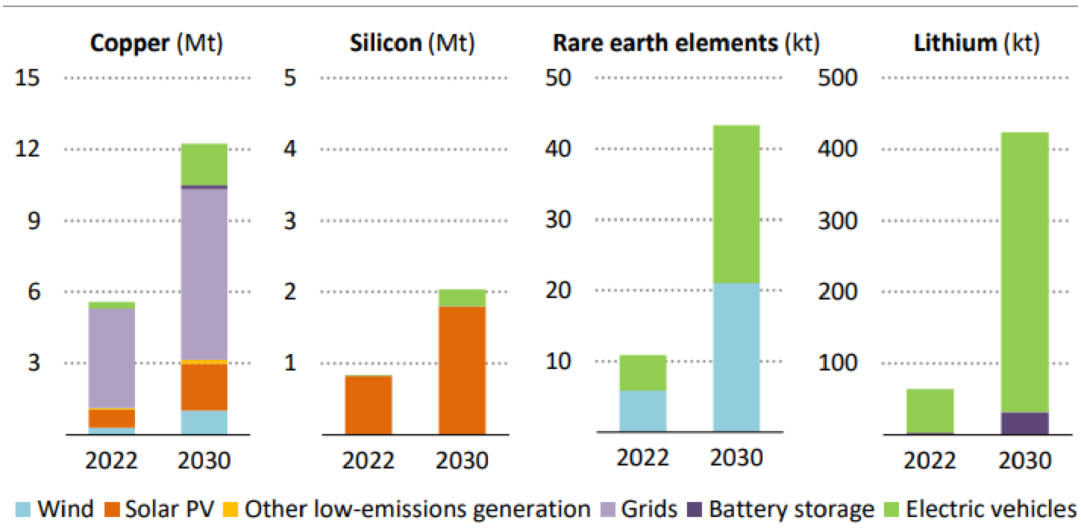

Figure 32 - Demand for critical minerals for selected clean electricity supply and electrification technologies, in 2022 and 2030 (IEA, 2023a)

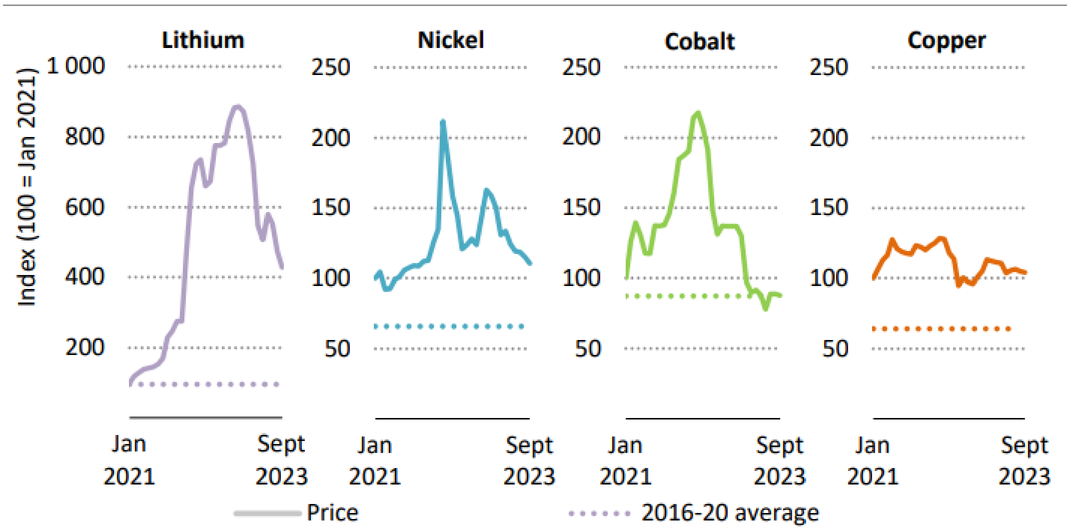

Figure 33 - Price developments for selected energy transition minerals and metals. (IEA, 2023a)

As of today, Russia dominates the supply of nickel, and Australia and Chile are key suppliers of lithium. While China holds around 70-77% of the world's capacity for processing lithium. This, along with the fact that the market for raw materials has always been volatile, makes it very difficult to predict future supplies and prices for these commodities (Svenska Kraftnät, 2022). However, according to the US Geological Survey (2022), the earth's total supply of lithium amounts to 89 million tons. Today's yearly extraction of lithium amounts to 100,000 tons, highlighting the challenges associated with extracting the mineral. Transport & Environment (2022) are also optimistic for the future, and they believe that the price of lithium will stabilise in a few years. They suggest that the current strained situation will ease with the opening of more mines, considering the time required for new mine operations.

4.3.4 The Swedish Perspective

Energimyndigheten (2023b) states that the electricity consumption in Sweden increases in every future scenario — following the global trend of electrification. Figure 34 below shows the electricity consumption in 2010, 2015, and 2020. Furthermore, it shows the electricity consumption in the two scenarios "lower electrification" and "higher electrification". The electricity consumption in 2050 will be around 250 TWh in line with "lower electrification" and over 300 TWh according to "higher electrification". This is significantly higher than historical values - since 1990 the electricity consumption in Sweden has varied between 134 and 150 TWh.

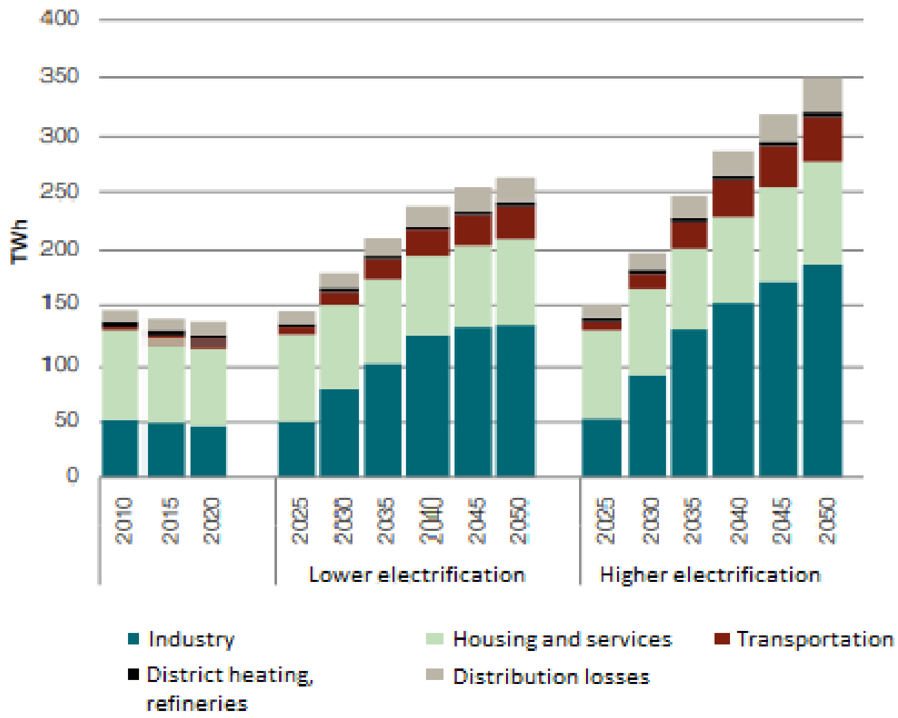

Figure 34 - Electricity usage in 2010, 2015, and 2020, as well as forecasts of future electricity usage in the two scenarios "Lower electrification" and "Higher electrification". (Energimyndigheten, 2023b)

According to Daniel Gustafsson, the head of the Power Systems department at Svenska Kraftnät, it is still unclear where the supply for this increased demand will come from. Gustafsson highlights the risks of higher electricity prices if the production rate doesn't rise, which may make Sweden very dependent on importing electricity. However, since there is a certain limit to how much electricity Sweden can import, it can lead to insufficient electricity production, which poses a risk to the grid. Furthermore, the grid in Sweden needs to be expanded to ensure a safe and reliable distribution (Ekerlid, 2023; Energimyndigheten, 2023b). Projections show that there is a need to build 7000 km of new power lines. This can be compared to the period 2000-2020, in which 600 km of power lines were built. (Ekerlid, 2023).

4.3.4.1 Batteries in Sweden

The increase in stationary battery storage and EVs is not only a global trend, but a trend in Sweden as well. As stated earlier, there are risks associated with these technologies, but battery storage and EVs are anticipated to be the main flexibility supply in the future (Energimyndigheten, 2023b; IEA, 2023a). An outline of BESS developers working in the European market is displayed in Appendix D. There is a clear increase in battery storage installations - both grid-scale and home batteries. However, it is not easy to find an exact number on how much battery storage capacity there is in Sweden. In a recent article written by von Schultz, Nohrstedt, and Askergren (2024), a survey of battery parks in Sweden was conducted. According to this article, there are currently 11 operational battery parks in Sweden, with a total combined capacity of 107 MWh. Furthermore, 27 parks, with a total capacity of 496 MWh, are under construction and expected to be operational in 2024. Additionally, 46 parks, with a total capacity of 2,851 MWh, are planned. The total cost of approximately one-third of the operational and under-construction facilities is 785 million SEK, indicating significant investment in battery parks.

Regarding home energy storage, Skatteverket has statistics on how many green deductions they have given for energy storage installations. In 2022, they gave 4 times more deductions compared to 2021, meaning that the sales of home batteries are growing rapidly (Skatteverket, n.d.a; Svensk Solenergi, 2024).

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5. **Empiricism,** Current Analysis

This chapter provides the theoretical model, empiricism and analysis of the company today. From which it provides a current analysis of Flower Infrastructure Technologies AB in which it describes how the company is operating today.

5.1 Introduction

The following chapter contains the empiricism and analysis of how the case company operates today. In order to use the theoretical framework described in 3.1 the current-day analysis will be presented in the major parts needed to use the models. Those being, the capabilities of the case company (RBV), value proposition, technology life cycle (TLC) and technology strategy.

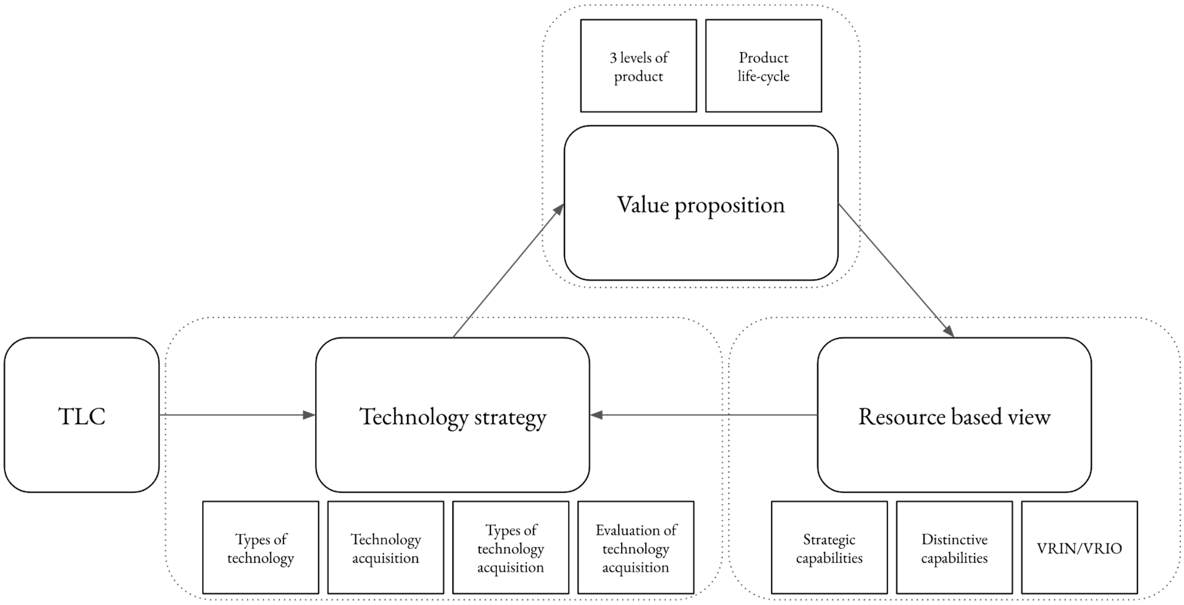

Figure 2 - Framework used in the current analysis

5.2 Case Company Value Proposition

The following Chapter aims to delve into the company's value proposition which was earlier explained in the theory Chapter (3.3). Emphasis is placed on the three levels of a product model to analyse the company's value proposition. The first level "core product", showcases what intrinsic value the buyer is acquiring. In the second level "actual product", the core product is transformed into an actual product and entails the product or service, brand name, packaging, quality, etc. The third and final level, "augmented product", includes value-added services, such as warranty, installation, and delivery.

The empirical evidence primarily obtained from interviews will constitute the major portion of the data. Additionally, other empirical findings will be incorporated. The analysis of this data will be summarised at the conclusion of this chapter and further consolidated in section 5.5.

5.2.1 General Input from Interviews on Value Proposition

Concerning the types of value creation at Flower today, multiple interviews provided different aspects of the VPP today.

5.2.1.1 Service Offering at Flower Today

Starting with the core service, there were multiple ways of interpreting it. One interviewee described the core value of their service to be that Flower "provides support services to Swedish power grids" and this is done by offering economic compensation to investors in making their assets more flexible which in turn increases the assets' production and distribution (Interviewee 3, 2024). While another interviewee went more in-depth, "By increasing the amount of renewable energy in the system, we face challenges in balancing it, requiring more services to stabilise the grid. We aim not only to participate in short-term markets and support services but also to engage more in total solutions and wholesale" (Interviewee 5, 2024). Several of the interviewees pointed out that the emphasis of the company is on enabling the energy transition, which for them means that Flower should not develop the whole value chain but rather should act as an assistant to all the different stakeholders and help everyone in a green transition (Interviewee 3, 2024; Interviewee 5, 2024; Interviewee 6, 2024). Interviewee 3 (2024) added: "We create value by providing support services to Swedish power grids, which means that we play a central role in supporting and strengthening the electricity grid. By offering financial compensation to those who invested in making their assets more flexible, we enable increased production and distribution. It is worth noting that the entire market for support services is in principle a procurement for an authority."

But how is the core service transformed into an actual product? At Flower, this is done through their VPP, which all interviewees brought up. The VPP acts as a way to assist with ancillary service controls where this could be done by, for example, FCR controlling, power refinery, or peak-shaving. But on the whole, Flower adds power grid assets to their catalogue and trades with them, thus it is mainly their VPP portfolio that realises the value creation. A central aspect of the VPP is also the usage of machine-learning models primarily used to assess the availability of assets. Also, Flower's MMO was brought up several times, from which their allocation models could extrapolate what kind of profits could be made by buying, selling or storing energy right now and in which markets. This kind of optimising is not done by competitors, as they often only focus on one market (Interviewee 2, 2024; Interviewee 3, 2024; Interviewee 5, 2024; Interviewee 6, 2024)

Looking into Flower's augmentations of their service offering, what distinguishes them the most from its competitors is their involvement throughout the entire value chain. Flower engages from the initial concept of a client desiring a battery, undertakes project development, and continues its commitment until the customer realises financial benefits, even extending to the battery's lifespan, which can span over 15 years. In other words, Flower does not only focus on optimising the batteries, but also on these important parts: integration, prequalification, being approved by Svenska kraftnät, actual trading, and invoicing. (Interviewee 6, 2024; Interviewee 7, 2024; Interviewee 8, 2024). Service stacking was also brought up as a value-added service, which falls in as an augmentation of the product (Interviewee 5. 2024). Flower also augments its service by educating its customers and partners on why the flexibility need is increasing and why ancillary service markets are of interest. Furthermore, good communication between Flower and its partners assists Flower in providing improved services (Interviewee 8, 2024; Interviewee 9, 2024). Flower has also developed a portal, which can be accessed by their partners and through this portal the partners get an overview of their batteries. They can follow how much revenue the batteries are generating, the number of charges/discharges, as well as other relevant information (Interviewee 6, 2024).

5.2.2 Summary and Analysis of Flowers Current Value Proposition

The empiricism presented above will now be summarised and the data will be analysed as it is placed in the three levels of a product model, which will be shown in Figure 35 below.

To begin with, when the interviewees were asked about what they perceive the "core product" to be, almost everyone responded with "providing support services to Svenska Kraftnät". This does however not correspond to the three levels of a product model, thus the first level is about determining what intrinsic value the buyer is seeking. What Flower does is ensure a reliable and efficient power grid supply - assisting with maintaining the power grid frequency at 50 Hz. Thus this is placed as the "core product" per the three levels of a product model. This intrinsic value may differ among different types of customers. However, it is this value that the main business model is built upon, and this consequently leads to economic benefits for other customers and partners.

So how do Flower assist in ensuring a reliable and efficient power grid supply? As stated by the interviewees, Flower offers supply services to Svenska Kraftnät. This is made possible by operating a VPP, which includes many different assets, either owned by Flower themselves or by partners. Flower's VPP is unique from competitors as it incorporates a Multi-Market Optimisation (MMO), paired with complex ML algorithms. Through this, Flower can predict weather changes and price fluctuations through multiple markets, optimising the revenue of the asset by ensuring it is trading in the current most profitable market - which changes constantly. A vital part of Flower's solution is the reliance on BESSs, which store energy and are controlled by Flower's software. Through all of this, Flower can provide ancillary services, power refinery, peak-shaving, and wholesaling. These aspects are considered to be the foundation that forms Flower's actual product and are thus placed in the second level of the three levels of a product model.

Flower offers a lot of value-added services, which all fall into the third level of the three levels of a product model, and thus these are placed accordingly. The most significant part here is service stacking and Flower's involvement throughout the entire value chain, which includes important steps, such as prequalification on the ancillary markets and integration. Furthermore, Flower also focuses on educating the customer or partners, which involves a lot of communication and this assists in a better understanding of the client's needs and thus improved tailored solutions. All of the partners also get access to the Flower portal, in which they can follow important statistics of the asset: revenue, charge cycles, etc. As stated, these parts act merely as augmentations of their offerings, but generate a significant competitive advantage: these value-added services are not only appreciated by partners, but they also exhibit Flower's deep knowledge about the industry.

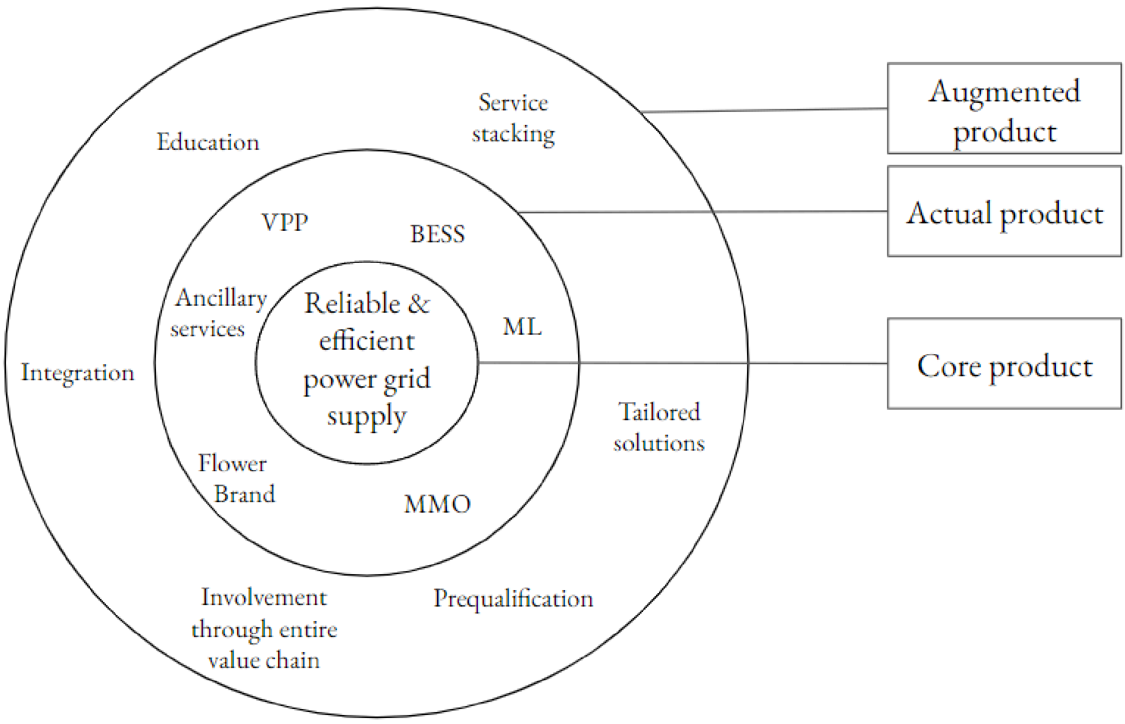

Figure 35 - Three levels of products at Flower today

5.3 Case Company Capabilities

The following Chapter aims to delve into the case company's capabilities which was earlier explained in the theory Chapter (3.2). In summary, capabilities are categorised into resources and competencies. Resources represent what a company possesses, while competencies signify the actions the company can undertake with its resources. To better follow the purpose of this thesis, resources and competencies are segmented into distinctive, dynamic, and threshold components. Furthermore, to offer a more comprehensive representation, resources are subdivided into physical, human, organisational, or financial resources.

The empiricism that was found was mainly procured through interviews that will provide the bulk of the data, after which, some other empiricism will also be presented. This will from this data be summarised at the end of each Chapter and further as a summation in 5.2.5. After this, all capabilities are presented, and the VRIO model will be applied to showcase how important different capabilities are.

5.3.1 Resources Presented From the Interviews at Flower

Throughout the interviews with Flower employees, significant emphasis was placed on the resources currently utilised by the company. Foremost, financial capital emerged as a vital resource necessary for the case company's operations, especially considering its involvement in high CapEx and OpEx projects, where financials establish project parameters. (Interviewee 6, 2023)

In operating their facilities, several essential resources were highlighted, including alarm systems, lighting, land, batteries (BESS), power grid connection points, offices, and temporary facilities. These resources are deemed as thresholds for operating within the VPP sphere. A big part of operating these facilities comes from having a system integrator, or a power plant controller, which involves SCADA subsystems and the management subsystem. (Interviewee 6, 2023)

However, the most pivotal resource for Flower remains its VPP. In every interview, the VPP surfaced as integral, projected to remain the case company's cornerstone service. The VPP relies on various resources, as described in the interviews. For instance, the implementation of control systems and connection with grid-scale batteries, although it's important to note that the company is not presently operating the batteries but instead just detailing how they will be used. (Interviewee 2, 2023; Interviewee 3, 2023; Interviewee 4, 2023; Interviewee 5, 2023; Interviewee 6, 2023)

Numerous interviewees stressed the utilisation of various modelling tools. Allocation models, VPP control systems, ML algorithms, modelling tools, prospect models, and power grid optimization tools emerged as crucial resources. These tools primarily contributed to two aspects: multinodal optimization and power refinery within the VPP. (Interviewee 3, 2023; Interviewee 5, 2023; Interviewee 6, 2023)

A notable addition to Flower's resources was the development and usage of a new product, the Flower Hub. This device functions as a miniature VPP, connecting to residential batteries.

To create these resources, an extensive knowledge base was imperative. Knowledge in ancillary systems, algorithmic development (for FCR-D, FCR-N, aFRR, FFR and Nord Pool Spot), energy markets, hardware integration, IT, ML, and TSO activation systems were deemed critical for continual value creation at Flower. A multidisciplinary team, predominantly composed of engineers was instrumental in achieving this (Interviewee 3, 2023; Interviewee 4, 2023; Interviewee 5, 2023; Interviewee 6, 2023). "We have recruited many new employees, and about 85% of them have an engineering background, creating a strong engineering orientation," noted one respondent (Interviewee 3, 2023). This orientation supported a fail-fast, learn-fast mentality, encouraging innovation and fostering an innovation-friendly culture (Interviewee 3, 2023; Interviewee 6, 2023).

Additionally, Flower's flat organisational structure empowered employees, enabling inclusivity in decision-making processes. Trust and transparency were highly valued within the organisation. However, some employees perceived the case company's organised chaos as both beneficial, fostering a technology-agnostic approach, and challenging, for example by prolonging the onboarding process for new employees. This means that they are not afraid to try something new and do what's needed in order to make it happen but this also sometimes leads to a longer project plan that is perhaps possible.

Lastly, the importance of relationships in the market was underscored by many interviewees, emphasising the critical nature of maintaining these relationships for optimal outcomes for all involved parties.

5.3.2 Other Resources Found at Flower Today

From Flowers's annual report and their product offerings outside of the interviews, several more resources were interpreted. These are all presented in different outreach situations like newsletters or annual reports. One thing that's often shown there is the forecasting, optimisation and trading software that the company is currently using. Also, the more knowledge-driven aspects such as asset-backend trading, asset-led trading, grid stability, BESS optimisation and congestion management weren't brought up during the interviews but are displayed on Flowers's homepage. Finally, none of the interviews gave that much information about who the partners Flower used were or else they asked for them to be anonymous. Some of the publicly known are SENS, Nybro Energy, Ramboll and Ellevio. (My news desk, 2022c; Flower Infrastructure Technologies AB, 2023a; Flower Infrastructure Technologies AB, 2023b; Flower Infrastructure AB, 2023c; Flowerhub, 2023; My news desk, 2022b; SENS, 2023)

5.3.3 Competencies Presented During Flowers Interviews

In much the same way as the resources, several competencies were brought in the Flower employee interviews.

As with the resources, their fail-fast, learn-fast mentality was also brought up as being one of their most important capabilities as it provided them with continual ways of improving upon themselves. This also circled back to their emphasis on technology and innovation described in their resource Chapter which has become one of their main ways of getting new technology incorporated into their company. (Interviewee 5, 2023; Interviewee 6, 2023)

The competencies discussed concerning competitive advantages predominantly revolved around effectively utilising their VPP which most interviewees specified. When concerning the various aspects of the VPP, the largest emphasis was placed on the operational aspects, including the intricate models developed using ML algorithms. Flower also put a large emphasis on their proficiencies, particularly in trading, which they underscored by their extensive knowledge base acquired in a relatively short timeframe. In ensuring the functionality of their VPP, several critical tasks also came into play. Their project required a broad knowledge base in everything from project development, which was required to navigate through various intricacies, to technics and technology, which was required as it gave Flower a competitive advantage in how the project could be performed. Furthermore, to operate the VPP there were certain necessities. For example, the application of sophisticated modelling and prediction tools and models, a point repeatedly highlighted by several interviewees, was often cited. Expanding on this, their ability to seamlessly integrate these tools into practical applications was identified as a key competence which was grounded in their power grid knowledge. This was also cited as necessary to even operate in their market.

5.3.4 Summation of Capabilities

As was described in the earlier Chapters many capabilities were found. From the empiricism, a summation of the different capabilities can be seen in Table 5, 6 and 7:

Table 5 - Table of Financial, Physical, Human and Organisational resources at Flower today

Financial	Physical	Human	Organisational
Financial capital Investments from among others (41an Invest, Ellevio Energy solutions, Quik Holding AB	Alarm systems for sites Allocation Models BESS Control systems for VPP Flower hub Grid-scale batteries Land to operate on Lights ML algorithms ML models Modelling tools Offices Prospect models Power Grid connection points Power grid optimisation tools Residential batteries Temporary facilities Virtual power plant Forecasting software Optimisation software Trading software	Ancillary system knowledge Algorithmic development (FCR-D, FCR-N, aFRR, FFR and Nord Pool Spot) Ancillary services market knowledge CAD knowledge Communication skills Energy knowledge Energy markets knowledge Energy System knowledge Financial knowledge Hardware integration knowledge IT knowledge ML knowledge Multidisciplinary team Negotiation skills Programming Competences, (for example, in HTTP, MTT and Cloud) Power refinery knowledge Project management knowledge Stakeholder management Technical knowhow Trading knowledge TSO knowledge (especially activation systems) Asset-backed trading Asset-led trading ML Congestion management BESS Optimisation Flower hub	Big engineering team Emphasis on innovation and technics Empowering the people to make to decisions Fail-fast, learn-fast Flat organisational structure Innovation friendly Multinodal optimisation Organised chaos Power refinery Relationships in the market Technology-agnostic approach Transparent organisation VPP Business network consisting of for example (SENS, Nybro Energis, Ramboll, Ellevio

Table 6 - Table of dynamic, distinctive and threshold resources at Flower today

Dynamic	Distinctive	Threshold
Flower hub Grid-scale batteries Emphasis on innovation and technics Empowering the people to make to decisions Fail-fast, learn-fast Flat organisational structure Innovation friendly Organised chaos Power refinery Relationships in the market Technology-agnostic approach Transparent organisation	Algorithmic development (FCR-D, FCR-N, aFRR, FFR and Nord Pool Spo) Ancillary services market knowledge Ancillary system knowledge Big engineering team Control systems for VPP Energy markets knowledge Energy System knowledge Financial knowledge Hardware integration knowledge ML algorithms ML knowledge ML models Multinodal optimisation Modelling tools Multidisciplinary team Negotiation skills Power refinery knowledge Power grid optimisation tools Project management knowledge Prospect models Residential batteries Stakeholder management Technical knowhow Trading knowledge TSO knowledge (especially activation systems) Virtual power plant (VPP)	Alarm systems for sites Allocation Models BESS CAD knowledge Communication skills Energy knowledge Financial capital IT knowledge Offices Power Grid connection points Temporary facilities IoT for communication Programming

Table 7 - Table of dynamic, distinctive and threshold competencies at Flower today

Dynamic	Distinctive	Threshold
Fail-fast, learn-fast Large emphasis on technology and innovation	VPP ML models to prospect the availability of energy ML algorithms to help with trading Broad knowledge from technics to project management Traders	Application of modelling Application of prediction Prediction models Modelling tools Power grid knowledge

5.3.5 Application of the VRIO Model on Flowers Capabilities

To comprehensively analyse each capability, they have been categorised within the VRIO model. To recap, this model evaluates capabilities based on their ability to create value, their rarity, the costliness of imitation, and the extent to which they are fully utilised by the organisation. The fulfilment of these criteria enables us to conclude various aspects, including the competitive implications, economic performance, and whether the capability should be considered a strength or weakness for the company.

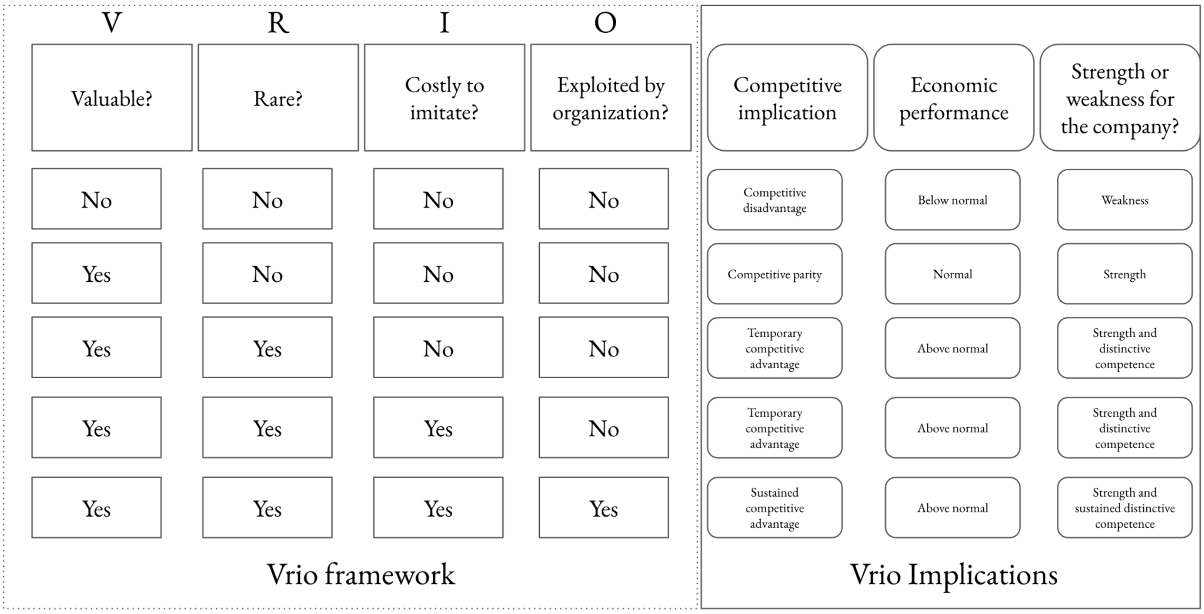

Figure 10 - The relationship between the VRIO model and competitive implication, economic performance, as well as, strengths and weaknesses of the company

In order to perform this analysis some evaluations were needed. Some of the resources and capabilities were seen as intertwined which led to some capabilities being grouped. The groupings were as follows:

Table 8 - Table of current capabilities at Flower and how they're grouped in this thesis

Capability:	**Other parts integrated**
Ancillary system knowledge	System knowledge, market knowledge [both of the ancillary service market]
Big engineering team	
Broad knowledge from technology to project management	Technical knowhow, Multidisciplinary team, Project management knowledge
Business network consisting of for example (SENS, Nybro Energis, Ramboll, Ellevio)	Relationships in the market
CAD knowledge	
Communication skills	
Emphasis on innovation and technology	Fail-fast, learn-fast, Innovation friendly, Technology-agnostic approach
Energy system knowledge	Energy knowledge, Power grid knowledge, TSO knowledge (especially activation systems)
Flat organisational structure	Empowering the people to make to decisions
Flower hub	

Grid-scale batteries	BESS, BESS Optimisation
Hardware integration knowledge	IoT for communication
Investments from among others (41an Invest, Ellevio Energy solutions, Quik Holding AB	
IT knowledge	
ML	ML algorithms, ML algorithms to help with trading, ML knowledge, ML models, ML models to prospect the availability of energy
MMO	Congestion management, Forecasting optimisation, Forecasting software, Modelling tools, Optimisation software, Prediction models
Multinodal optimisation	
Negotiation skills	
Offices	
Organised chaos	
Power refinery	Power refinery knowledge
Programming	Programming Competences, (for example, in HTTP, MTT and Cloud)
Residential batteries	
Sites	Alarm systems for sites, Land to operate on, Lights, Power Grid connection points
Stakeholder management	
Trading	Asset-backed trading, Financial knowledge, Traders, Trading knowledge & Trading Software
Transparent organisation	Internally transparent
VPP	Control systems for VPP, Power grid optimisation tools

With this grouping a better analysis could be made which resulted in the table of capabilities being shown in Table 9 below. An explanation for the capabilities placement is presented in Appendix B.

Table 9 - Table of current capabilities and their ranking in with the VRIO model

Capability:	V	R	I	O
Ancillary system knowledge	TRUE	TRUE	FALSE	FALSE
Big engineering team	TRUE	FALSE	FALSE	FALSE
Broad knowledge from technology to project management	TRUE	FALSE	FALSE	FALSE
Business network consisting of for example (SENS, Nybro Energis, Ramboll, Ellevio)	TRUE	TRUE	TRUE	FALSE
CAD knowledge	TRUE	FALSE	FALSE	FALSE
Communication skills	TRUE	FALSE	FALSE	FALSE
Emphasis on innovation and technology	TRUE	TRUE	TRUE	TRUE
Energy system knowledge	TRUE	FALSE	FALSE	FALSE
Flat organisational structure	TRUE	FALSE	FALSE	FALSE
Flower hub	TRUE	TRUE	TRUE	FALSE
Grid-scale batteries	TRUE	TRUE	TRUE	FALSE
Hardware integration knowledge	TRUE	FALSE	FALSE	FALSE
Investments from among others (41an Invest, Ellevio Energy solutions, Quik Holding AB	TRUE	FALSE	FALSE	FALSE
IT knowledge	TRUE	FALSE	FALSE	FALSE
ML	TRUE	TRUE	TRUE	TRUE
MMO	TRUE	TRUE	TRUE	TRUE
Multinodal optimisation	TRUE	TRUE	TRUE	TRUE
Negotiation skills	TRUE	FALSE	FALSE	FALSE
Offices	TRUE	FALSE	FALSE	FALSE
Organised chaos	FALSE	FALSE	FALSE	FALSE
Power refinery	TRUE	TRUE	TRUE	TRUE
Programming	TRUE	FALSE	FALSE	FALSE
Residential batteries	TRUE	FALSE	FALSE	FALSE
Sites	TRUE	FALSE	FALSE	FALSE
Stakeholder management	TRUE	FALSE	FALSE	FALSE
Trading	TRUE	TRUE	TRUE	TRUE
Transparent organisation	TRUE	FALSE	FALSE	FALSE
VPP	TRUE	TRUE	TRUE	TRUE

As can be seen there are some 28 general capabilities from which 7 are currently clearing all criterias. The one most important for this thesis is grid-scale batteries which is clearing the V, R and I part of the VRIO analysis. However, as Flower is just buying these and using them as assets they aren't being fully as fully exploited by the organisation as they can be.

5.4 Case Company Technology Life Cycle: Battery Energy Storage Systems

The following section aims to provide a more in-depth exploration of the BESS, as it is a vital component of Flower's VPP. It holds significance in the context of this thesis, which delves into the development of high-tech services. Consequently, the section will concentrate on the functionality requirements that Flower attributes to a BESS, the specific type of BESS employed by Flower currently, and the current augmentations of the BESS product today. Furthermore, the BESS technology will be placed in the technology life cycle, which was described in Chapter 3.4.

The empiricism in this chapter was mainly procured through interviews with Flower personnel. Furthermore, data from the pre-study will be used to help place the BESS technology in the technology life cycle.

5.4.1 Functionality Requirements

There were also functionality requirements for their batteries that were brought up in the interviews. The functionality requirements were generally set by a Transmission System Operator (TSO) that regulates what can be added to the market (Interviewee 4, 2023). These could also change depending on what the battery is used for. For instance, an FCR implementation needs better response time while a wholesale battery needs a higher capacity and reliability. Especially concerning activation systems. Going into more detail, the batteries always had to have a certain speed to control the effect of the work done when a signal arrived. Sample time was therefore important as it sets how fast one can sample data from the batteries. Other aspects were surveillance and manipulation of the batteries as this helps with monitoring and therefore the continual usage of the batteries (Interviewee 2, 2023). Interviewee 2 (2023) further shared that the most important part was robustness, the battery simply needs to always work for Flower to make the best use of it. If it's down on the wrong day this could potentially cost the company more than 100,000 SEK. To then use the batteries more effectively State of Charge and State of Health monitoring was important as they are used to feed what output one wants from the battery (Interviewee 4, 2023).

5.4.2 The BESS Product Flower Uses Today

When operating the BESS product, visualisation was seen as crucial in providing clear and comprehensive insights into how the battery operates and how it can be used. This could include basic details for easy understanding by individuals with limited technical expertise as well as more in-depth information that could be reached if desired. Some of these more in-depth data that was brought forward were "financial data, revenue streams, SoC, PoC, Frequency, Active Power, Reactive power, as well as, what the total amount of charge and discharge during the day has been. These aspects should also be catalogued to make it easy for operators to go back and further research what has happened, what was the battery's response and what were the consequences of the response. What was made clear in the interviews was that the most important aspect of implementing the BESS would be to help with decision-making in other aspects of the company and that the establishment of a BESS of their own would be crucial in fostering a greater understanding and collaboration between team members and also consolidating relevant information onto one single platform. Beyond these requirements liability, and troubleshooting were also brought up as aspects of interest however these weren't that heavily dived into. (Interviewee 4, 2023)

However, something that everyone who worked with batteries talked about was the need to get in contact with customer services as there are often problems with the batteries (Interviewee 2, 2023; Interviewee 4, 2023). This made most of them prefer one supplier over the rest and was the main augmentation that the interviewees emphasised. One other important part was the delivery times which often made an impact on which supplier to go with. The cost was also brought up as an important part of getting the right battery, however, the cost could never overcome the impact of buying a worse product. Especially in dealing with support and reliability if these aspects weren't satisfactory then the whole operation could worsen. Delivery time was also brought up several times as a big aspect in deciding on what battery the company used. As the different delivery times are highly volatile depending on what the BESS companies' suppliers experience with difficulties, the risks of late delivery times always had to be a part of the consideration. (Interviewee 4, 2023)

5.4.3 Augmentation of BESS Product Today

The BESS in the meantime has a couple of augmentations that the people working with it proposed as the most important ones. By far the most emphasised was the customer support system which every person who used the system talked about in their interviews. Interviewee 2 (2023) said: "For me, who works with the batteries after the fact, regardless of the price, it is valuable to be able to pick up the phone and talk to someone about any problems. There is added value in that, although I have not carried out any careful financial calculations." The problems with using Chinese suppliers were therefore brought forward as, for example, some of the manuals might not even be translated into English. And even though Flowers's suppliers might be European, the battery cells are often Chinese which makes it so that the battery cells and BESS are inconsistent with the steering and communication due to different systems being used. (Interviewee 2, 2023)

5.4.4 Where is BESS Today

In order to examine how far the BESS technology has developed, information from the prestudy (section 4.3) will be used and analysed in order to place it in the technology life cycle.

As could be seen in Figure 30 (section 4.3.3), development costs for battery storage have fallen in the past years. A reason for this is that factories are capitalising on standardisation and shorter lead times. However, the future path for cost development is still unclear. Various aspects pose a risk to the development of batteries, the biggest one being: the supply and price developments for critical minerals used in batteries. In the last three years, there was a big surge in the prices of critical minerals, which has recovered but still remains higher than historical averages. Furthermore, the world relies on a few actors for the supply of critical minerals, which makes future predictions even harder. Still, the deployment of new BESSs is on the rise, which is evident in Sweden, the scope of this thesis. Both grid-scale batteries and home batteries are increasing significantly. However, an interviewee at Flower sees potential for a significantly accelerated pace in the expansion of BESS deployments. (Interviewee 10, 2024).

From this, it can be said that the BESS technology is best placed somewhere in the growth phase, thus this phase signifies a time when production processes improve, product design stabilises, entrants decrease etc. This placement is further corroborated by the growth stage in the product life cycle (see 3.3.3), a stage that signifies a period of increasing sales, which is evident today. Furthermore, as the theory stated in section 3.4, determining how long this phase will last is a difficult task, thus the possibility of further large developments in this technology is possible.

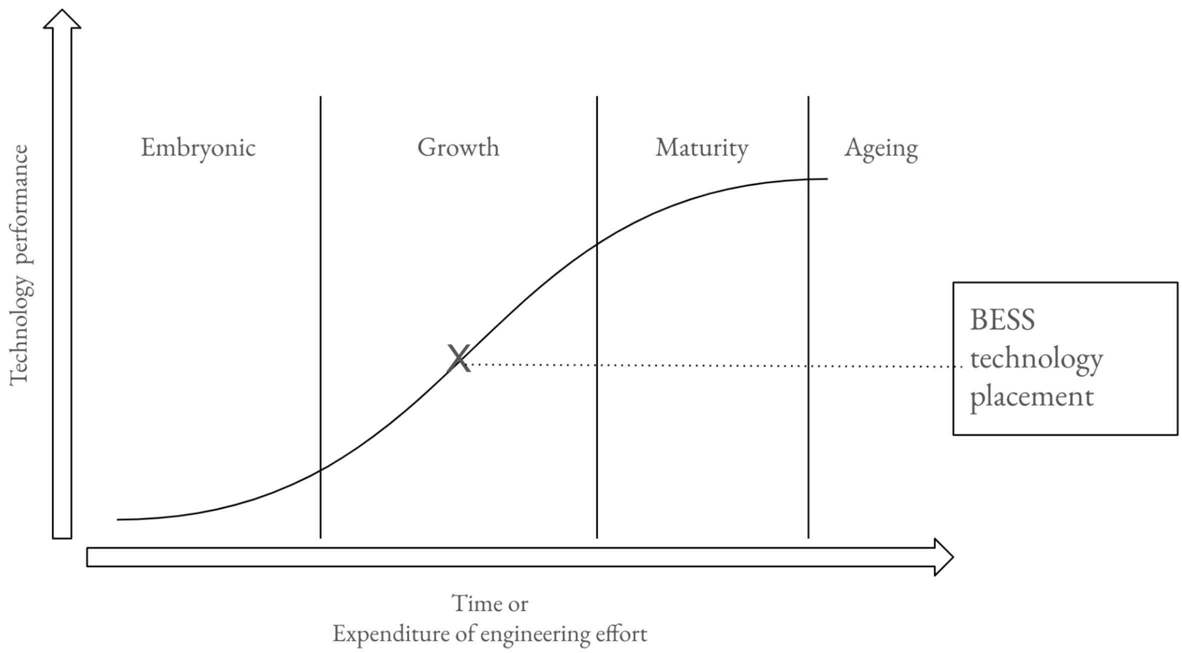

Figure 36 - Placement of BESS technology in the technology life cycle.

5.5 Case Company Technology Strategy at Flower Today

The following Chapter aims to delve into the case company's technology acquisition which was earlier explained in the theory Chapter (3.5). In summary, the role of technology acquisition is a subpart of technology strategy which primarily consists of how a company procures new knowledge. In order to use it one needs to know what sorts of technologies your company can create and what your company can do with these technologies. To make this, there is also a need to evaluate what the case company's relative standing is today, how urgent the acquisition is, how big of a commitment the company is prepared to make in order to create the new technology, and what type of characteristic the technology will have.

The empiricism presented in this chapter was mainly procured through interviews that will provide the bulk of the data, after which, some other empiricism will also be presented. This will from this data be summarised at the end of each Chapter and a summary will be provided in 5.4.6

5.5.1 Technology Strategy Presented From Interviews at Flower Today

During the interviews with Flower several questions were asked about how they procure technology today. Mostly every interviewee said that the main way of acquiring technology today was through developing it internally. "We buy almost nothing, either models, controls, systems or something else. Our focus is on building and refining our own solutions in order to ensure a high degree of adaptation and control of our own technologies" (Interviewee 5, 2023). However, one interviewee also said that they often buy certain technical assets when they are needed. (Interviewee 2, 2023)

What they do put a large emphasis on right now is the need to recruit a lot of new talent. As shown in 4.2 the company is growing rapidly and thus it's dealing with for example recruitment sprees to build a larger workforce and headhunting for more challenging positions (Interviewee 5, 2023). One interviewee however talked about the onboarding of new employees as a bit more difficult for Flower than other companies as they are currently a "scale up" and with that, there comes a bit of "organised chaos", from which it will take a longer time to become a productive employee. (Interviewee 6, 2023)

A large focus on technology acquisition was through the fail-fast, learn-fast mindset. They are not afraid to try something, a model or such and if it doesn't work they move on or pivot to something else. An example of this is the control system for EVs (electric vehicles): "We started to work with private customers with the plan to control EVs, but after a couple of months we realised that it got too complicated. We shifted instead towards EV chargers, but then we found a partner with a thousand EV charges that wanted us to test it. Thereafter we pivoted towards a B2B-model [from which] we successively developed and broadened our assets we control". (Interviewee 5, 2023)

5.5.2 Flowers' Relative Standing in the BESS Sphere

When considering Flowers' relative standing in the BESS sphere one thing first needs to be explained. Throughout the interviews, it was said that Flower isn't currently operating in the BESS sphere, despite that they have written on their homepage that they are "Expanding upon and harnessing our core capabilities, we are rapidly emerging as a leading developer of grid-scale Battery Energy Storage Systems (BESS), earning the trust of grid owners throughout Europe." (Flower Infrastructure AB, 2023d). This is however because the company is currently providing reasons for other companies to operate in the sphere by helping them with, for example, running projects, finding network connections, and helping with building contracts and so on (Interviewee 2, 2024; Interviewee 7, 2024). To clarify, that means that they are not able today to create a BESS from scratch and they are not able to design a BESS or plug one in when it's in place, but they can assist in various aspects around the deployment of a BESS.

5.5.3 Flower's Urgency of BESS Acquisition

When asked about the urgency of BESS acquisition almost every interviewee answered in the same way. The acquisition level is currently low at Flower as the company is currently happy with their suppliers and there are so many uncertainties in operating in their sphere that they can't say for certain that developing their own would be of interest (Interviewee 6, 2023). However, several interviewees said that the acquisition level could change if either an economic incentive or a value-creating benefit came up (Interviewee 3, 2023; Interviewee 4, 2023; Interviewee 8, 2024; Interviewee 11, 2024; Interviewee 13, 2024)

When considering the economic incentives, most interviewees said that the reason for this was for Flowers's end product to be commercial in the long term they need to bring down the cost, primarily the CapEx, of their services. However, this will not be a problem for the next few years. (Interviewee 2, 2024)

When considering the value-creating aspects of developing their own BESS most interviewees said that a bigger influence on the design of the BESS would greatly improve how a BESS could be designed in order to be better optimised for either ancillary services or wholesaling. The viability of this reasoning however can be in question as none of the interviewees could provide any problems with their current BESS parameters.

5.5.4 Flower's Commitment/Investment Potential in Technology Acquisition

When considering the commitment of Flower towards developing a BESS technology the general opinions were much the same as with urgency. The general opinion provided by almost all of the interviewees was that the company does not currently need to develop a BESS of their own, but that there could be some benefits (the same benefits as in 5.4.4) in doing so. The primary reason provided however for why they should develop their own system right now is that there are long horizons for developing these systems and if Flower wants to have a BESS developed by themselves they would need to start with the development as soon as possible.

5.5.5 Categorisation of Flowers technologies

As described in the earlier Chapters a lot of technologies were described provided from the interviews and company sources. This empiricism has been categorised into the same categories as Ford's model of basic-, distinctive- and external technologies in order to get a better understanding of them. These are the same as were brought up in 5.2.1.

Interviews

From the interviews several technologies were provided. These were much the same as the ones presented in 5.2.1 and 5.2.2 and will thus not be re-explained in this chapter. They have however been placed in a distinction between basic-, distinctive-, and external technologies following the theory (presented in 3.5.1) after an analysis of what type of influence the technology has at Flower.

Table 10 - Table of Flowers current technologies provided from interviews split into basic-, distinctive- and external technologies

Basic Technology	Distinctive technology	External technology
Alarm systems for sites Allocation Models Ancillary service systems(FCR-D, FCR-N, aFRR, FFR and Nord Pool Spot) Algorithmic development Ancillary services market knowledge Big engineering team CAD knowledge Communication skills Flat organisational structure Emphasis on innovation and technics Energy knowledge Energy markets knowledge Energy System knowledge Fail-fast to learn-fast Financial capital Financial knowledge Hardware integration knowledge IT knowledge Land to operate on Lights ML knowledge ML algorithms ML models Modelling tools Multidisciplinary team Negotiation skills Offices Organised chaos Programming Competences, (for example, in HTTP, MTT and Cloud) Power refinery knowledge Power grid connection points Power grid optimisation tools Project management knowledge Prospect models Relationships in the market Stakeholder management Technical knowhow Temporary facilities Transparent organisation Trading knowledge TSO knowledge (especially activation systems)	Control systems for VPP Multinodal optimisation Flower hub Virtual power plant Empowering the people to make to decisions Innovation friendly Technology-agnostic approach VPP	Batteries Grid-scale batteries Residential batteries

First-hand Account

The interviews did not cover everything and some information about some technologies that are used in the company was therefore procured through other means, such as Flowers' own reports. From their annual reports for example a more fleshed-out investment description was provided with who their biggest investment partners were, 41an Invest, Ellevio Energy Solutions and Quik Holding AB which would according to Ford be placed as a basic technology. Some other basic technologies provided in an old report were the usage of forecasting software, optimisation software, and trading software which as it's necessary to operate in the ancillary services market is placed as basic technology (Flower Infrastructure Technologies AB, 2022a). Also, some ways of optimising BESSs' are being presented on Flowers's homepage, this however is under contention as it does not appear that the company is currently assembling any BESS themselves (Flower Infrastructure Technologies AB, 2023c). Something that however was brought up in other ways through interviews was the usage of asset-backed trading which Flower uses to increase its profits and is something that not so many competitors are using, this has therefore been placed as a distinctive technology. Also as the interviews were mainly about the implementation of BESS into the power grid not much focus was pointed at the flowerhub which as it's not their main focus was placed as a basic technology (Flowerhub, 2023). Finally, some more business network connections were provided from newspapers for example, SENS, Nybro Energies and Ramboll (My news desk, 2022c; Flower Infrastructure Technologies AB, 2023a; Flower Infrastructure Technologies AB, 2023b; Flower Infrastructure AB, 2023c; Flowerhub, 2023; My news desk, 2022b; SENS, 2023)

Table 11 - Table of Flowers current technologies provided first-hand accounts split into basic-, distinctive- and external technologies

Basic Technology	Distinctive technology	External technology
Business network consisting of for example (SENS, Nybro Energis, Ramboll, Ellevio) Congestion management BESS Optimisation Flower hub Forecasting software Investments from among others (41an Invest, Ellevio Energy solutions, Quik Holding AB) Optimisation software Trading software	Asset-backed trading	BESS

5.6 Summary of the Case Company

To summarise this chapter, first, the framework used in this thesis is recalled. This framework lays the foundation for navigating through the analysis to work towards answering the purpose of the study: "... *to describe the development of high-tech services in the energy sector in Sweden by analysing the consequences of technology acquisition and knowledge basis in companies.* ." Each component of this framework is addressed throughout the analysis. The focus was on understanding the static of where the company and the industry are today while also getting glimpses into the dynamics of how these parts are changing.

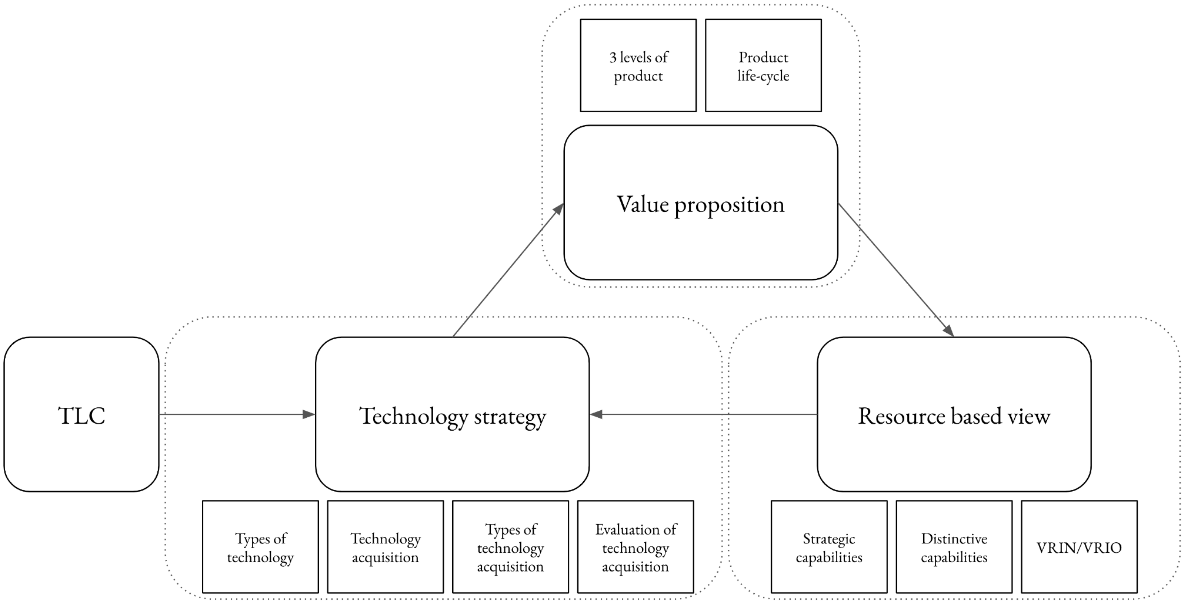

Figure 2 - Framework used in the current analysis

Following the framework, first the case company's value proposition was analysed and described using the three levels of a product. The company's value proposition was described as having the core product of providing reliable and efficient power grid supply. This is enabled through their current products, primarily the VPP and enhanced through various ways of augmenting the product. Primarily through being a part of the entire value chain, service stacking and education. A more expansive placement of every part in the three levels of a product is showcased in Figure 35 below.

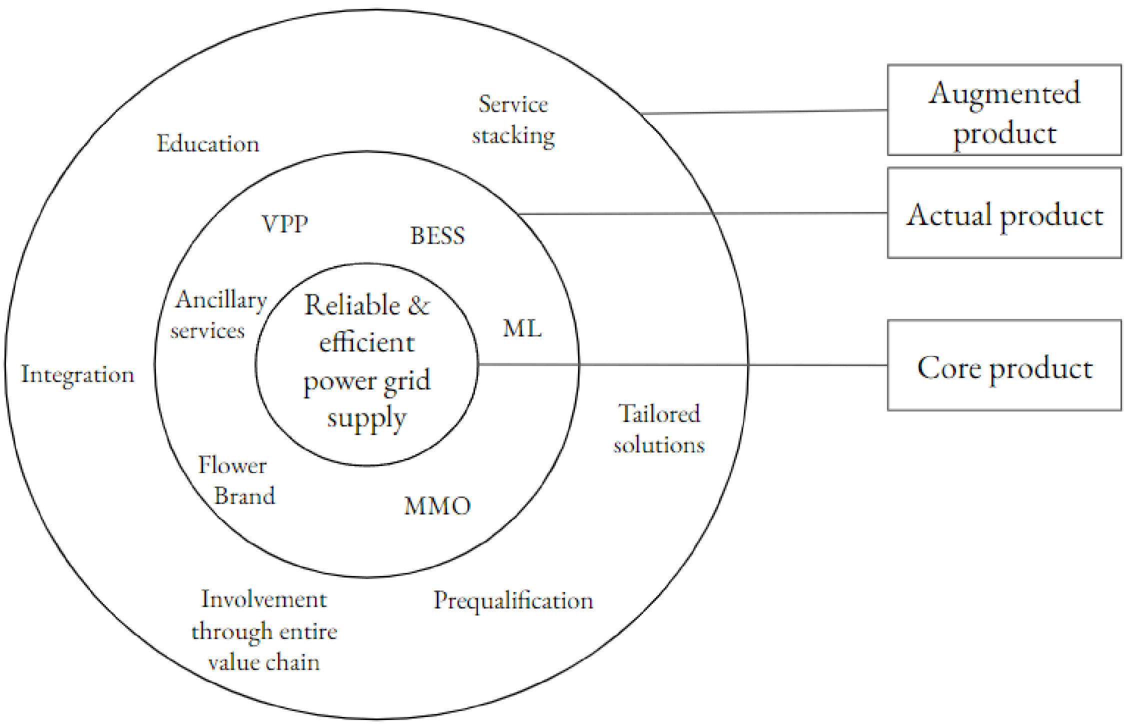

Figure 35 - Three levels of products at Flower today

The next part of the framework uses the RBV model to find the resources and competencies that are present at the company today. The resources are categorised into financial, physical, human and organisational. Then they are also categorised into dynamic, distinctive, and threshold resources. The competencies found were also categorised into dynamic, distinctive, and threshold. The result of this part is that the main distinctive capability Flower has today is their VPP and assets for the VPP. Their connection to BESS is currently an external physical resource that they aren't taking any steps towards producing themselves. A summary of every capability analysed is displayed in the three tables below:

Table 12 - Summary of Flower current Financial, Physical, Human and Organisational resources

Financial	Physical	Human	Organisational
Financial capital Investments from among others (41an Invest, Ellevio Energy solutions, Quik Holding AB	Alarm systems for sites Allocation Models BESS Control systems for VPP Flower hub Grid-scale batteries Land to operate on Lights ML algorithms ML models Modelling tools Offices Prospect models Power Grid connection points Power grid optimisation tools Residential batteries Temporary facilities Virtual power plant Forecasting software Optimisation software Trading software	Ancillary system knowledge Algorithmic development (FCR-D, FCR-N, aFRR, FFR and Nord Pool Spot) Ancillary services market knowledge CAD knowledge Communication skills Energy knowledge Energy markets knowledge Energy System knowledge Financial knowledge Hardware integration knowledge IT knowledge ML knowledge Multidisciplinary team Negotiation skills Programming Competences, (for example, in HTTP, MTT and Cloud) Power refinery knowledge Project management knowledge Stakeholder management Technical knowhow Trading knowledge TSO knowledge (especially activation systems) Asset-backed trading Asset-led trading ML Congestion management BESS Optimisation Flower hub	Big engineering team Emphasis on innovation and technics Empowering the people to make to decisions Fail-fast, learn-fast Flat organisational structure Innovation friendly Multinodal optimisation Organised chaos Power refinery Relationships in the market Technology-agnostic approach Transparent organisation VPP Business network consisting of for example (SENS, Nybro Energis, Ramboll, Ellevio

Table 13 - Summary of Flower current dynamic, distinctive and threshold resources

Dynamic	Distinctive	Threshold
Flower hub Grid-scale batteries Emphasis on innovation and technics Empowering the people to make to decisions Fail-fast, learn-fast Flat organisational structure Innovation friendly Organised chaos Power refinery Relationships in the market Technology-agnostic approach Transparent organisation	Algorithmic development (FCR-D, FCR-N, aFRR, FFR and Nord Pool Spot) Ancillary services market knowledge Ancillary system knowledge Big engineering team Control systems for VPP Energy markets knowledge Energy System knowledge Financial knowledge Hardware integration knowledge ML algorithms ML knowledge ML models Multinodal optimisation Modelling tools Multidisciplinary team Negotiation skills Power refinery knowledge Power grid optimisation tools Project management knowledge Prospect models Residential batteries Stakeholder management Technical knowhow Trading knowledge TSO knowledge (especially activation systems) Virtual power plant (VPP)	Alarm systems for sites Allocation Models Batteries CAD knowledge Communication skills Energy knowledge Financial capital IT knowledge Offices Power Grid connection points Temporary facilities IoT for communication Programming

Table 14 - Summary of Flowers current dynamic, distinctive and threshold competencies.

Dynamic	Distinctive	Threshold
Fail-fast, learn-fast Large emphasis on technology and innovation	VPP ML models to prospect the availability of energy ML algorithms to help with trading Broad knowledge from technics to project management Traders	Application of modelling Application of prediction Prediction models Modelling tools Power grid knowledge

After the case company's capabilities were established and categorised, they were analysed using the VRIO theory, to determine which capabilities provide the best competitive advantage for the company. Of special interest in this thesis was the placement of Grid-scale batteries that are seen as providing a temporary competitive advantage and above-normal economic performance driver since they provide value, are considered rare, as well as, are costly to imitate. The results of the other resources are provided in Table 9.

Table 9 - Table of current capabilities and their ranking in with the VRIO model

Capability:	V	R	I	O
Ancillary system knowledge	TRUE	TRUE	FALSE	FALSE
Big engineering team	TRUE	FALSE	FALSE	FALSE
Broad knowledge from technology to project management	TRUE	FALSE	FALSE	FALSE
Business network consisting of for example (SENS, Nybro Energis, Ramboll, Ellevio)	TRUE	TRUE	TRUE	FALSE
CAD knowledge	TRUE	FALSE	FALSE	FALSE
Communication skills	TRUE	FALSE	FALSE	FALSE
Emphasis on innovation and technology	TRUE	TRUE	TRUE	TRUE
Energy system knowledge	TRUE	FALSE	FALSE	FALSE
Flat organisational structure	TRUE	FALSE	FALSE	FALSE
Flower hub	TRUE	TRUE	TRUE	FALSE
Grid-scale batteries	TRUE	TRUE	TRUE	FALSE
Hardware integration knowledge	TRUE	FALSE	FALSE	FALSE
Investments from among others (41an Invest, Ellevio Energy solutions, Quik Holding AB	TRUE	FALSE	FALSE	FALSE
IT knowledge	TRUE	FALSE	FALSE	FALSE
ML	TRUE	TRUE	TRUE	TRUE
MMO	TRUE	TRUE	TRUE	TRUE
Multinodal optimisation	TRUE	TRUE	TRUE	TRUE
Negotiation skills	TRUE	FALSE	FALSE	FALSE
Offices	TRUE	FALSE	FALSE	FALSE
Organised chaos	FALSE	FALSE	FALSE	FALSE
Power refinery	TRUE	TRUE	TRUE	TRUE
Programming	TRUE	FALSE	FALSE	FALSE
Residential batteries	TRUE	FALSE	FALSE	FALSE
Sites	TRUE	FALSE	FALSE	FALSE
Stakeholder management	TRUE	FALSE	FALSE	FALSE
Trading	TRUE	TRUE	TRUE	TRUE
Transparent organisation	TRUE	FALSE	FALSE	FALSE
VPP	TRUE	TRUE	TRUE	TRUE

The next step in the framework was to determine how much the BESS technology has evolved. This was done using the model for the technology life cycle, coupled with the product life cycle. BESS is currently considered to be in the growth phase, see Figure 36, primarily as the technology is seeing improvements regarding manufacturing and coherent reductions in costs, but also an increase in deployments, especially in Sweden.

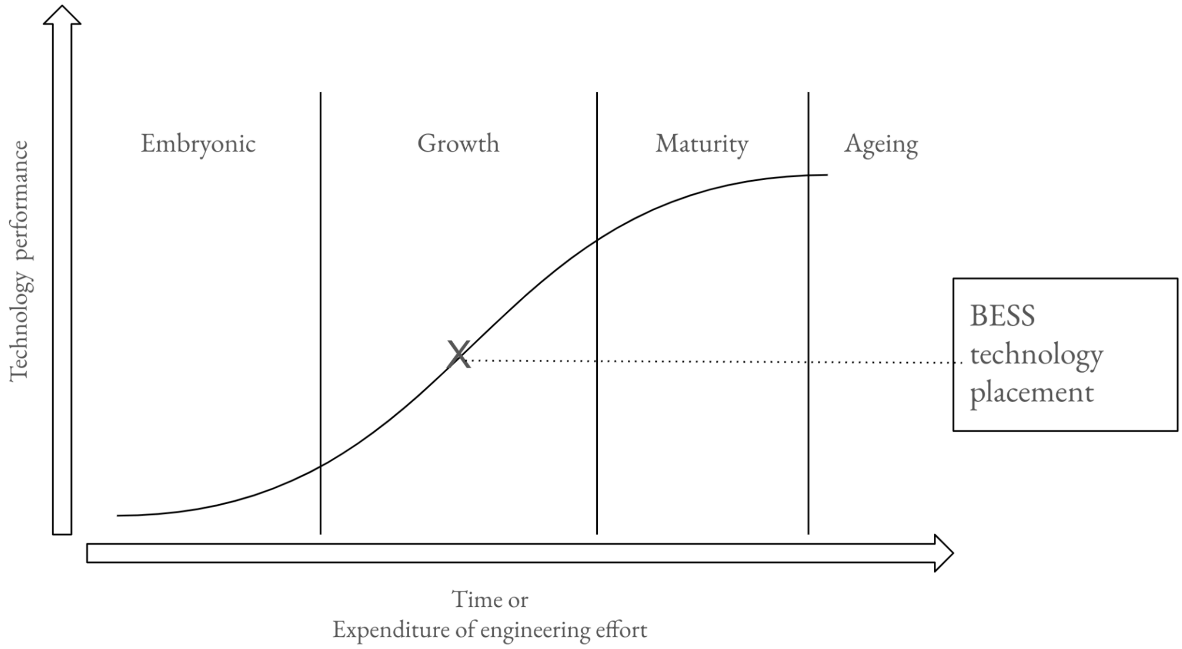

Figure 36 - Placement of BESS technology in the technology life cycle.

From this an analysis of how the company is currently using technology acquisition today. Here you can say that the company is currently mostly using in-house R&D where the company strives towards developing everything itself. The BESS product, however, is something that Flower currently doesn't develop on its own and where the main drivers towards developing them would be economical. An analysis of the capabilities was performed to better understand what kind of technology the different capabilities are and therefore how they should be treated. A showcase of this analysis is provided in the table below.

Table 15 - Summary of Flowers technologies split into basic-, distinctive- and external technologies

Basic Technology	Distinctive technology	External technology
Alarm systems for sites Allocation Models Ancillary service systems(FCR-D, FCR-N, aFRR, FFR and Nord Pool Spot) Algorithmic development Ancillary services market knowledge Big engineering team CAD knowledge Communication skills Flat organisational structure	Control systems for VPP Multinodal optimisation Flower hub Virtual power plant Empowering the people to make to decisions Innovation friendly Technology-agnostic approach VPP Asset-backed trading	Batteries Grid-scale batteries Residential batteries

Emphasis on innovation and technics Energy knowledge Energy markets knowledge Energy System knowledge Fail-fast to learn-fast Financial capital Financial knowledge Hardware integration knowledge IT knowledge Land to operate on Lights ML knowledge ML algorithms ML models Modelling tools Multidisciplinary team Negotiation skills Offices Organised chaos Programming Competences, (for example, in HTTP, MTT and Cloud) Power refinery knowledge Power grid connection points Power grid optimisation tools Project management knowledge Prospect models Relationships in the market Stakeholder management Technical knowhow Temporary facilities Transparent organisation Trading knowledge TSO knowledge (especially activation systems) Business network consisting of for example (SENS, Nybro Energis, Ramboll, Ellevio) Congestion management BESS Optimisation Flower hub Forecasting software Investments from among others (41an Invest, Ellevio Energy solutions, Quik Holding AB) Optimisation software Trading software		

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6. **Empiricism and Analysis,** Future Analysis

This chapter presents the six scenarios which were used in this thesis to understand the future. From these scenarios, it uses the theoretical models, empiricism and analysis of the future to conclude what type of differences each scenario would entail.

6.1 Introduction

As this thesis focuses on the development of high-tech services, our investigation will centre on BESSs, crucial for the optimal functioning of VPPs. Exploring the significance of BESS within the context of high-tech service evolution is essential, as these advanced systems play a vital role in enhancing the efficiency and capabilities of VPPs. This follows the structure given in Chapter 2.2.

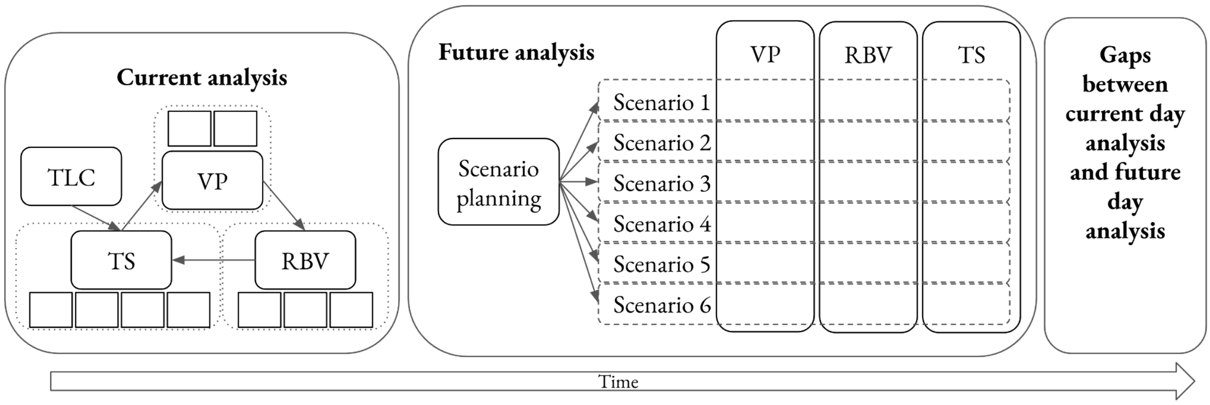

Figure 3 - Overview of how the different models will be used in the current and future analysis implemented into the research strategy

In order to do this, this chapter provides the empiricism and analysis to analyse what changes an implementation of a BESS would introduce following the framework provided by the research strategy.

It begins by showcasing how scenario planning has been utilised to explore various pathways into the future. It is followed by a review of the consequences these pathways would have on the three major theories introduced in this thesis. To conclude the chapter, there will be a summary of the different scenarios for each of the future trajectories, encapsulating all that has been learned throughout the preceding chapters. An overview of the contents of each chapter is displayed in Figure 37 below.

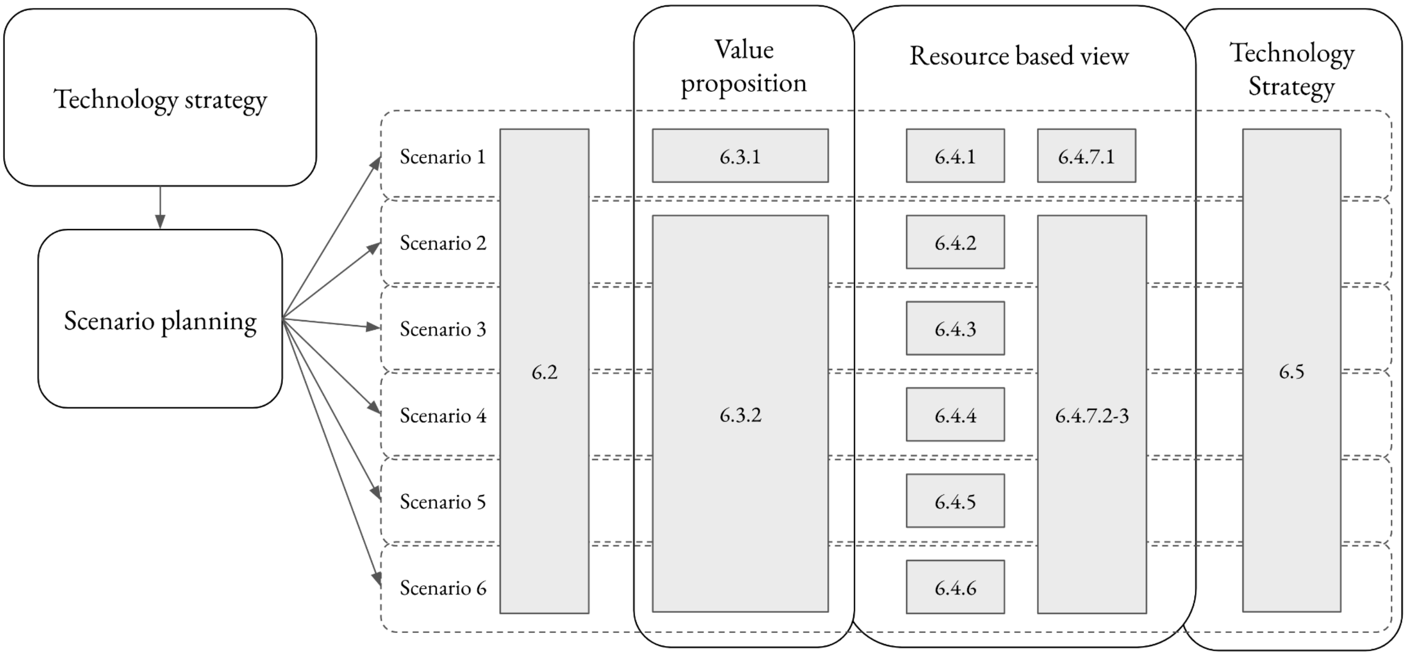

Figure 37 - A showcase of the theory has been used to create the 6 cases in this chapter. Where the chapters in grey include the relevant analysis.

6.2 Scenario Planning and Presentation of the Different Scenarios

As was described in chapter 2.4 this thesis will use scenario planning to best achieve the purpose of this thesis. This following part will therefore use the TAIDA model described in 3.6 to present the different scenarios, from which, the following chapters will conduct the future day analysis.

Prerequisites

As outlined in the TAIDA model, the creation of scenarios involves addressing certain prerequisites. Initially, the current day system needs to be analysed which has been presented in the introduction of the thesis along with the analysis in chapter 5, the empiricism from chapter 4 and the theory in chapter 3. Following this, there's a need to understand what question needs to be solved, in this thesis case, that is the purpose of the thesis which was described in part 1.2. Additionally, a time horizon needs to be presented. In this thesis, the time horizon was chosen through an interview with the case company which asked for a time horizon of 3 years into the future. After which, it becomes imperative to establish the past and present as a starting point for scenario development. In this thesis, this reference point is set at the commencement of the study on October 16, 2023. With the problem formulations in place and a defined starting point, the subsequent step involves a comprehensive analysis of the current situation.

T - Tracking

As was described in the theory, this part mainly consists of tracking new changes and trends in the environment. This thesis however does not deal with trying to find trends or changes, only what changes might lead to. Therefore, no analysis of trends will be done, as the authors will only rely on the work presented by earlier authors. For the background, the trends presented in the prestudy will be used, and for the case company, the trends posed on the company itself, presented in chapters 4 and 5, will be used.

A - Analysing

With the prerequisites and tracking presented, the rest of this chapter will mainly consist of the analysis of future scenarios. The scenarios that will be analysed haven't been proposed by us but are based on the ways of conducting technology acquisition proposed by Davenport. He said in his theory that the 7 aspects that drive technology acquisition are

- Vintage plough back
- Market leverage
- Co-evolution with customers
- R&D plough back
- Co-evolution with technology partners
- Co-evolution with suppliers
- International focus: surviving the gusher

All of these are introduced in chapter 3.5.4. However, one of the pathways forward involves creating an international focus, which is beyond the scope of this thesis; thus, this aspect has been omitted. Davenport has also concluded that the acquisition drivers mentioned above, provide 6 methods of conducting technology acquisition. These methods are:

- In-house R&D
- Lead users
- Network and alliances
- Merger and acquisition
- Technology licensing
- Contracted out R&D

All except one of these 6 are included in this thesis as scenarios of implementing BESS acquisition at Flower. The one omitted is the lead user acquisition method since it depends on the fact that the company implementing that method needs to already be an industry leader position which from the chapter 5.4.2 was proven to not be the case. This results in 5 scenarios from Davenport's theory. Finally, another aspect that is needed in order to evaluate these scenarios is the usage of a baseline scenario where the implementation of BESS development is omitted. This provides us with 6 scenarios in total.

A slight adjustment in showcasing these scenarios has also been made to better align with what Lindgren and Bandhold (2009) refer to as their guidelines for effective scenario communication. Given the complexity of some of Davenport's technology acquisition loops, a more accessible name has been introduced for each acquisition scenario.

6.2.1 Presenting the different scenarios

With the analysis underway there are 6 different scenarios which will be used. The scenarios will be referred to by the following names:

1. Continue as usual
2. Internal R&D
3. Joint venture
4. Merger and acquisition
5. Technology licensing
6. Contracted out R&D

In order to showcase these scenarios in an organised manner they will all be presented below with a short introduction to what the future in that scenario would look like.

6.2.1.1 Continue as Usual

The Continue as usual scenario is an attempt to evaluate what a Flower infrastructure AB would look like in the future (three years horizon) if Flower decides to continue without implementing BESS development into their operations. In this future scenario, Flower continues to refine and expand its existing business model to cultivate improvement and growth. Thus Flower will continue to focus on enabling and handling flexibility, by optimising ancillary services, grid services (e.g. peak-shaving), wholesale and financial trading, which was also corroborated by one of the interviewees (Interviewee 11, 2024). This aligns with their long-term goal of enhancing the MMO and will be done by service stacking and exposure to more markets (Interviewee 3, 2024; Interviewee 9, 2024). Based on the interviews conducted with Flower personnel, it was observed that the interviewees did not perceive the future implementation of BESS development as essential for Flower's survival (Interviewee 7, 2024). Thus, the development of batteries is not considered necessary, as it does not align with their long-term goals and diverges from their current business activities.

As discussed in Chapter 4.3, battery storage is experiencing rapid growth, which Flower will capitalise on by forming more partnerships in the coming three years. As analysed in section 5.3.1.1, Flower's VPP portfolio is crucial for realising value creation. The benefits of expanding the asset portfolio will be twofold: Firstly, with more assets in the portfolio, more information is gathered for the VPP, facilitating better predictions. This, as described in the theory chapter 3.5.4, creates feedback loops of continual value creation but also provides larger technology acquisition incorporated into the company. Secondly, the increased number of assets boosts available energy capacity to support the power grid. Therefore, Flower will prioritise further expansion of this portfolio, as the evident potential for growth continues to increase. However, as Chapter 4.3 further discussed, the BESS industry is dependent on critical minerals used to manufacture batteries, forming a bottleneck. This poses a threat to Flower's future business, whether or not they implement BESS development, as the bottleneck exists at an early stage in the value chain, where Flower would have little or no impact.

The prices for ancillary services in Sweden are anticipated to decrease, aligning more closely with the prices observed in Europe (Interviewee 7, 2024; Interviewee 11, 2024). The exact timing of this anticipated price reduction remains uncertain. According to an article by von Schultz, Nohrstedt and Askergren (2024), it was speculated that this price drop might occur as early as 2024 or 2025. With the possibility of this occurring within the next three years, Flower is likely to encounter extended payback periods on their projects, which is something that they are already preparing for (Interviewee 7, 2024).

Continuing as usual means Flower continues working with their BESS suppliers. All of the interviewees had positive attitudes towards current suppliers, emphasising that the communication with the suppliers was good and helpful. Further elaborations from interviewee 2 (2024) were that the competition among BESS suppliers is high, highlighting the likelihood that these suppliers are likely to be of high quality or competence. Thus, in this scenario over the next three years, Flower will continue working with the same suppliers.

To conclude this future scenario, Flower will have restructured its organisation to accommodate the anticipated growth. The company will secure new, larger offices, and implement new communication methods to streamline interactions across various domains in the company.

6.2.1.2 Internal R&D

The next scenario is the usage of internal R&D to develop their own BESS product. This is a scenario that is driven by Flower making a corporate diversification attempt which leads to starting a BESS team that after 3 years creates its first line of BESS products.

To do this, Flower would need to start investing heavily in the developments directly, there might however be some shortcuts that can be made along the road. As the company isn’t currently developing their own BESS, they could start by making smaller systems which are attached to Flower Hubs. This could ease the entry barriers and start their implementation of the system when moving into the future. When making this several evaluations have to be made. As this is a diversification attempt outside the core competencies of the firm Flower would need to acquire this new knowledge either through hiring or the usage of the vintage plough back method discussed in 3.5.3.

To evaluate what is needed to develop a BESS, appendix C has been put together with information about what a BESS is, what needs to be included with it and what general considerations have to be made when developing your own. As this thesis doesn't really need a greater evaluation a quick summary is instead provided below:

- ➢ Feasibility studies
- ➢ Grid connection studies
- ➢ Site investigations
- ➢ Consultation with local Council and government agencies
- ➢ Establishing agreements with landowners
- ➢ Planning and environmental studies and approvals
- ➢ Detailed design
- ➢ Preparation of management plans following the development approval
- ➢ Investment decision and raising equity to fund the Project
- ➢ Procurement of contractors and components

Another aspect is the need to restructure the company departments when implementing BESS development into Flower. BESS development is highly specialised and therefore requires a research department and a manufacturing or assembly site that is currently absent in Flower's existing structure. As BESS units also are composed of numerous components and assembly processes, a storage and manufacturing facility would be essential to ensure the quality and efficiency of production. A consequence of this would also be the additional personnel in both the assembly site as well as the R&D department. These resources would also necessitate a demand for dedicated space for research and development. This comes with components and equipment which are included in just the assembly site resource.

When it comes to the BESS itself that the company wants to develop it's hard to say what type of system they want to aim towards. For example, from the interviews, a large emphasis was put on that Flower wants to create products with a high degree of complexity to discourage competitors and also encourage the continual development of competence at the company. However, some interviewees said that for this product, as it wouldn't be their focus, they could also develop an easier system. Here Flower needs to evaluate what type of system they want to develop for the future. (Interviewee 3, 2023; Interviewee 6, 2024)

Something that needs to be discussed with this part is that the usage of diversification is associated with synergies that might come to happen if the company fully realises the value of the BESS. These have also been somewhat discussed during the interviews where for example one interviewee brought up that they would be faster and better able to control the effect of the batteries. They would also have more control over the sample time and how to process data from the batteries which is extra important in the FCR market as it's highly dependent on fast response times (Svenska kraftnät, 2024). They could also get better customer support as they would no longer be required to talk with external support when there is a problem with the products but instead, everything would be inside of their company. This can be recalled in the interviews where the interviewees stressed the need for great customer support as quick fixes are needed or there will be penalty charges. These faster response times inside the systems would also lead to higher compatibility which would increase the robustness of the system. Finally, there could also be more information gained from the whole system which could be used internally to improve the system, improve the MMO and also display more information for customers thus bringing more value to the product. (Interviewee 2, 2023; Interviewee 3, 2023)

6.2.1.3 Joint Venture

One of the most common ways of combining resources between two companies and combining their expertise and value creation is the usage of a joint venture (Barney, 2013; NI Business, n.d.a). A joint venture is an agreed-upon arrangement where Flower and another company have (in this thesis) after three years reached a consensus on what the two companies would like to mutually benefit from and from which, they have started creating their own BESS.

To showcase this scenario some parts need to be chosen, the first one being a partnered company (Barney, 2013; NI Business, n.d.b). An ideal partner would here have resources or capabilities that complement Flowers' own as well as share the culture between the two businesses (Barney, 2013; NI Business, n.d.b; NI Business, n.d.c). Motivation is also an important aspect. Usually, the biggest motivation for one partner to get a larger competitive advantage but something that should also be considered is that in order to have a successful implementation the two companies involved in the joint venture need to be in a win-win situation (Barney, 2013; Dents, C. 2023; Tsang, E.W.K, 2000). It's therefore not a situation where only Flower can profit from what another company brings. For this thesis, the partnered company would create a BESS which is well suited for Flower's desired implementation while Flower itself provides for example a new or safer revenue stream for the partnered company or knowledge sharing in VPP/MMO knowledge.

Usually, starting a joint venture allows for some benefits. Some of the more normal ones are, for example, the exploitation of economies of scale as the company, depending on the size of the partnered company (Barney, 2013). There might also be learning opportunities from the company and Flower will probably learn more about the development of a BESS when working with other companies (Barney, 2013; NI Business, n.d.a; Shan, G., Walker, B., & Kogut, B.., 1994; Hamel, G., 1991; Si, S. X., &

Bruton, G. D., 1999). This might also trickle down and lead to more improvements in different parts of the value chain, resulting in the overall enhancement of the entire value chain (Ajmal & Kristianto, 2012). Another aspect is that a larger entity is usually less susceptible towards financial risks as the joint venture could better manage its way through the market with combined revenue (Barney, 2013; NI Business, n.d.a; Emami, A. et al., 2022). For this thesis, one thing of special interest is the way a joint venture might lead to a low-cost entry into new markets, new industries, and new industry segments since the venture can be implemented into the BESS industry which lowers diversification risks by reducing the percentual costs (Barney, 2013; NI Business, n.d.a). It has also been proven that managing uncertainty is easier for joint ventures than smaller scale-ups, thus making this an interesting option in Flowers's case (Barney, 2013; Emami, A. Et. al., 2022).

However, to create this venture some aspects are seen as crucial. A clear business rationale for change, alignment with your existing business strategy, agreeing with their management, governance and decision processes early and the need for both companies to have a sufficient plan for implementation, operations and exit contingencies. This would in our example be represented by a firm with the same business culture, with a high focus on trust and transparency while respecting that the two companies are distinct entities, and for Flower to have arranged with the partnered company a structured process for how contingencies might be handled. To make this happen the two companies would need clear communication arrangements between organisations/teams, financial arrangements, protection of your interests, for example, trade secrets, day-to-day and strategic decision-making, dispute resolution procedures and if either party can pursue other business during the joint venture. It should also consist of bank account arrangements, as well as, a legal structure for the two companies. (NI Business, n.d.d).

However, there might also be some risks involved with this arrangement. For example, statistics show that approximately 50-70% of joint venture fail to achieve their intended objectives (Prange, C. & Mayrhofer, U., 2015). Moreover, there's a risk that other firms might gain insights into your products or services, potentially lowering barriers to their entry into your market (Barney, 2013). Employee commitment may also be a concern, as operating within a joint venture could lead to less allegiance among employees who may inherently trust the partnered company (Beshay, K, 2018). There are also difficulties in flexibility that might occur if the joint venture is too rigid, thus making the way in which Flower narrows the market uncertainties harder. For example, by acquiring unwanted baggage from a rigid venture deal (Barney, 2019). These risks emphasise the importance of careful consideration and detailed agreements to mitigate potential pitfalls in a joint venture. This, for example, by not constricting the companies' independence and their own way of using their specific capabilities. These risks can be minimised by taking the earlier described steps to guarantee a well-thought-out one.

6.2.1.4 Mergers and Acquisitions

In this scenario, Flower will expand its business through a merger and acquisition (M&A). There are different types of mergers and acquisitions (Hayes, 2023). Boiled down, mergers involve integrating one business with another and sharing control over the combined entity. Acquisitions, on the other hand, entail purchasing another business (NI Business, n.d.e). Typically, merger and acquisition are classified based on the degree to which the business activities of the acquired organisation are related to those of the acquiring entity, falling into four main types (Cartwright & Cooper, 1996):

- **Vertical:** Involves the combination of two organisations from successive processes within the same industry. For example, a manufacturer may acquire a series of retail outlets.
- **Horizontal:** Involves the combination of two similar organisations in the same industry.
- **Conglomerate:** The acquired organisation is in an unrelated field to the acquirer.
- **Concentric:** The acquired organisation is in an unfamiliar but related field to which the acquirer wishes to expand. For example: a TV manufacturer buying a cable company.

In this thesis, the case company, Flower, is seeking to venture into the assembly of BESSs. Among the four types of M&A mentioned above, this strategic move positions Flower in the category of (backwards) vertical M&A, as the processes involved in what Flower does today and assembling BESSs are successive within the same industry. Proceeding with this strategic move and achieving a successful M&A comes with a set of benefits but also challenges. The most important benefits Flower will gain are new competencies and resources and reduced industry entry barriers (CFI Team, n.d.) since this is outside of their core business and they do not have the necessary resources and competencies. However, there are also challenges associated with this move, the most significant one being potential culture clashes between the firms (Corporate Finance Institute, n.d.a). Interviewee 10 (2024) emphasised that if Flower were to acquire another company, the culture of the acquired company should align with that of Flower.

Now the question is: How to find the right firm for a M&A? The process involves creating a targeted shortlist, developing a profile of the desired firm, and gathering relevant information on markets, companies, products, and services (NI Business, n.d.f). Flower's strategies for doing this should include: considering existing commercial relationships (e.g. Alfen), utilising senior staff networks, and seeking assistance from professional advisers. Opportunities for growth through merger or acquisition may arise from undervalued businesses, underutilised assets, potential relocations, poor management, or complementary products/services - thus these are the things Flower should look for. When approaching a target business, it is crucial to communicate the purpose, financing plans, and future intentions clearly. Consideration of the target's selling plans and compatibility with your company is essential for successful mergers. Seeking professional advice from solicitors or accountants is recommended throughout the process (NI Business, n.d.f.).

Evidence from M&A research suggests that while takeovers yield short-term gains for target firms, the long-term benefits for acquiring firms are questionable, varying widely between firms (Agrawal & Jaffe, 2000). This is something for Flower to keep in mind as their reasons for implementing a BESS development, are related to long-term success. Furthermore, the examination of human resources, a vital component of M&As, is often overlooked. This analogy can be drawn to the process of buying a house based on factors such as price, location, and aesthetics, only to realise the interior (representing employees) dynamics during the actual move-in. Predicting the reactions of human resources in M&A is always a complex task. Employee-related challenges and human conflicts commonly arise following the consolidation of two companies. (Cartwright & Cooper, 1996).

6.2.1.5 Technology licensing

Technology licensing is also an interesting way of conducting technology acquisition that is described in the vintage plough back and market segment leverage parts of Davenport's model from chapter 3.5.4. Technology licencing is a contractual arrangement in which the licenser's patents, trademarks, service marks, copyrights, trade secrets, or other intellectual property may be sold or made available to a licensee that in part is paid for by compensation, negotiated in advance between the parties (Privacy shield framework, n.d; WIPO, 2015; Parr & Sullivan, 1996). It's therefore a way of getting right at what someone else has developed and can thusly be a rather flexible pathway when expanding into a new market (WIPO, 2015). This however usually requires some reconciliations for the technology one might want to license. This is typically accomplished via financial transactions, although it is not obligatory to be conducted in that manner. They can also be in the form of licensing deals where for example one company licences its technology in return for access to a patent from the other company (Edgren & Skärvad, 2010).

In this thesis, the technology licensing will be showcased as Flower getting access to a BESS from a company operating in the European market. This licence provides them with the right to manufacture a BESS in Sweden as most of the judicial obstacles will already be satisfied. It will also consist of technology assistance that is often a part of a licensing deal (Edgren & Skärvad, 2010; WIPO, 2015). With this agreement, several benefits can come. If Flower is allowed to construct the products from what the licensee has provided they may try to move into a market provider position of these products. This might create new revenue streams for the licencing company, as well as Flower, while also providing Flower with a more stable partner. This is a normal tactic often used where licensees give priority to adopting a new technology and bringing its product to a market or the licensor and the licensee move simultaneously (Musandiwa &

Ngwakwe, 2022; Din, & Sun, 2023). This would be an attractive way for Flower to start developing BESS as Flower doesn't necessarily need to produce the technology itself as the company but can just procure it and thus circumnavigate many of the difficulties and risks associated with developing their own product.

However, a potential complication may arise if Flower decides to licence the product, as this would entail them not having as much control over the licence to the selected company. This could lead to problems as the licensee may implement technologies in ways that are not aligned with Flower's vision, potentially diluting the value that Flower could otherwise get from developing its own product (Privacy Shield framework, n.d.). There are also competitive risks associated with licensing, where the licensed technologies could be used by competitors, thereby reducing the potential entry barrier. This was one of the main advantages that interviewees highlighted when explaining why Flower should integrate a BESS into their company. There are also some financial drawbacks as licensing might not always result in substantial financial gains, particularly if market demand for the technology is limited. Additionally, licensing usually produces smaller profits for your company than exporting actual goods or services. And in some countries, adequately protecting the licensed technology from unauthorised use by third parties may be difficult (Privacy Shield framework, n.d.).

6.2.1.6 Contracted out R&D

In the sixth and final scenario, Flower will contract out its R&D on BESS. This means they will use their own BESS products in their projects within three years.

Contracted out (external) R&D refers to when a company hires external firms or research organisations, either public or private, to conduct creative work aimed at expanding knowledge and fostering innovation (UNESCO UIS, n.d.a). This scenario is similar to the internal R&D scenario, but in this case, Flower will stay focused on its core business (as discussed in 6.2.1.1) while external partners handle the R&D process. Finding and collaborating with new partners (investing in external R&D) can strain finances (Berchicci, 2014). Therefore, over the next three years, they need to raise capital to grow their existing business while also funding R&D initiatives.

External R&D does not always guarantee increased innovation and success. There is a threshold where collaboration becomes less effective, and excessive external input can hinder a company's progress compared to working alone. Instead, a moderate amount of external R&D can enhance innovative performance (Berchicci, 2014). Based on this, the utilisation of external R&D options will enable Flower to initiate its own R&D capabilities, including the establishment of facilities and expertise in the R&D domain. Moreover, this approach allows the company to engage consultants and experts to provide valuable assistance in the R&D endeavours. This step might become the first step towards BESS development.

Finding the right partners, consultants, or research experts can be challenging, time-consuming, and expensive. Therefore, Flower should maintain regular communication with potential partners, fostering strong and effective relationships. The research underscores the significance of partner relationships as a pivotal factor during outsourcing activities, particularly in high-tech environments (Cullen, Johnson & Sakano, 2000; Kedia & Lahiri, 2007; Gulati & Sytch, 2008). Additionally, Kedia and Lahiri (2007) emphasise the importance of the buyer trusting potential suppliers or partners regarding confidentiality and the security of sensitive information. However, before finding the right partners, Dr. Berchicci (2014) recommends considering three key points, which Flower will integrate into this scenario:

1. Assess your expertise and identify areas where external insights could be beneficial.
2. Concentrate your research efforts on a few specific areas to reduce the costs associated with finding and establishing partnerships. Quality partnerships in niche areas are more valuable than numerous acquaintances.
3. Allocate your efforts to new partnerships based on your familiarity with the subject matter. If you lack knowledge, dedicate about one-third of your efforts to forming new partnerships.

6.3 Future Value Proposition at Flower

As the capabilities of the company have now been presented, the next step in the framework is the new value proposition of the future scenarios which will be showcased in this chapter. The different subsections will be split into larger parts however as most of the future scenario's future value propositions overlap. The different scenarios that overlap are Internal R&D, Joint venture, Mergers and Acquisitions, Technology licensing, as well as, Contracted out R&D which will all be included in 6.3.2 while the Continue as usual scenario is presented in chapter 6.3.1.

6.3.1 Future Value Proposition in the Continue as Usual Scenario

For the scenario in which Flower continues as usual (as described in 6.2.1.1), the future value proposition will not change much. When the interviewees were asked about how they perceive that the future value proposition will change, their responses were uniform, stating that the future value proposition will continue on the same path. However, they emphasised that they will keep building on the existing value proposition in multiple ways (Interviewee 3, 2024; Interviewee 5, 2024; Interviewee 6, 2024). Improving the service stacking was brought up in multiple interviews as a natural way of improving. An interesting aspect was the aspect of increasing complexity. Service stacking was said to be an evolving state that created competitive advantages and entry barriers from competitors by increasing the complexity, thus making it harder to imitate (Interviewee 3, 2024; Interviewee 6, 2024).

Based on the "Continue as usual" scenario and the information provided in the paragraph above, it appears that the company's future value proposition will not differ significantly from today's value proposition. Despite the interviewees mentioning that service stacking could enhance their future value proposition, this concept is already incorporated into their current offerings. Rather, this feature will instead be improved. As a result, minimal changes are anticipated in their value proposition moving forward, and thus the three levels of Flower's solution will resemble the one outlined in section 5.3 (see Figure 38 below).

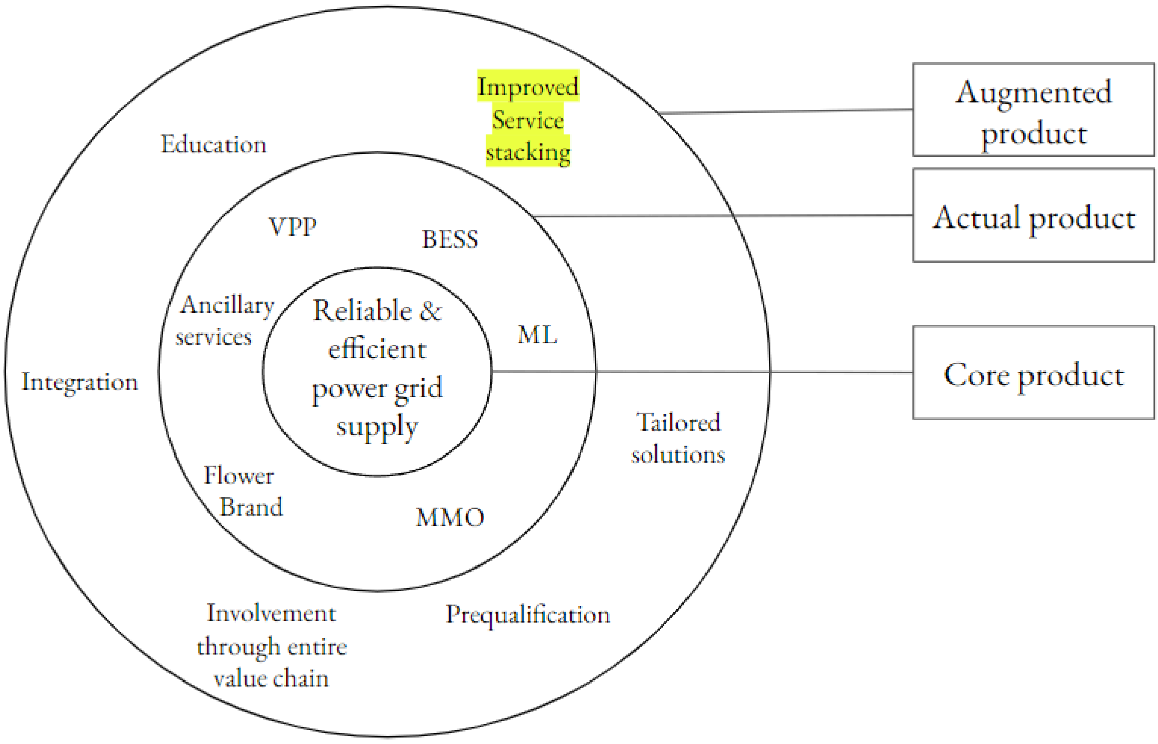

Figure 38 - Future value proposition in line with "Continue as usual scenario". The one change is improving the service stacking feature. The change is highlighted.

6.3.2 Future Value Proposition in Scenarios Implementing BESS

The interviewees were asked about their perspectives on how the future value proposition would change if Flower implemented the development of its own BESSs. The responses regarding this were also uniform, emphasising that such an implementation would lower the capital expenses (CapEx) for the projects, which are substantial today. As of the present moment, the large CapEx associated with projects in Sweden remains manageable. This is due to the immaturity of the FCR market in the region, characterised by high prices, consequently leading to fast payback times for the projects. However, the market is anticipated to mature in the foreseeable future. When this transition occurs, there is a likelihood that the prices in Sweden may align with those in Europe, where prices are lower. This potential alignment could pose a challenge for investment decisions, particularly given the persistently high CapEx associated with the projects (Interviewee 7, 2024; Interviewee 9, 2024).

Interviewee 8 (2024) stated that implementing the development of BESSs would also give Flower control over aspects such as size, design, and electrical systems. In other words, the value proposition would change in the way Flower designs the battery, benefitting the customers in the form of better warranty, system implementation and more knowledge of the system. Also, by implementing alert states into the BMS, troubleshooting could be made easier which would make it easier to use the BMS for identifying and addressing issues in the system (Interviewee 4, 2024). Another viewpoint was given by interviewee 10 (2024), who said that the development of BESSs would help Flower leverage the speed at which the company grows, and also accelerate the electrification. This however is not considered a change in the value proposition.

However, as mentioned earlier in the thesis, Flower's value creation primarily stems from its portfolio of assets, which it controls and optimises to generate additional revenue. Developing their own BESSs may not necessarily grant Flower greater autonomy over these assets, as they are already sufficiently open for Flower to exercise control as desired (Interviewee 11, 2024). Therefore, since this capability aligns with Flower's existing offerings, it may not represent a significant change in the future value proposition. However, developing their own BESS could enhance service stacking capabilities. In the initial stages of a project, Flower can determine the specific services the battery is intended to perform and develop accordingly, thereby improving the overall value proposition.

The most significant difference between today's and the future value proposition is the anticipated reduction in CapEx resulting from Flower's own BESS development. This reduction in CapEx could potentially lower costs for the end customer, as suggested by several interviewees. This, combined with improved system implementation, service stacking and warranty, will be the changes in the future value proposition, see Figure 39. Improved warranty, system implementation, and service stacking are placed on the "augmented level" of the three levels of a product model, as these are considered to be value-added services. Finally, the lower CapEx (or development costs), while not conventionally incorporated within the three levels of a product model, represents a fundamental aspect of the product's tangible attributes and operational efficiency. Its inclusion underscores a strategic shift towards emphasising cost-effectiveness and affordability, reflecting evolving market demands and enhancing the product's competitive edge in the marketplace. Because of this, lower CapEx is placed on the second level of the model.

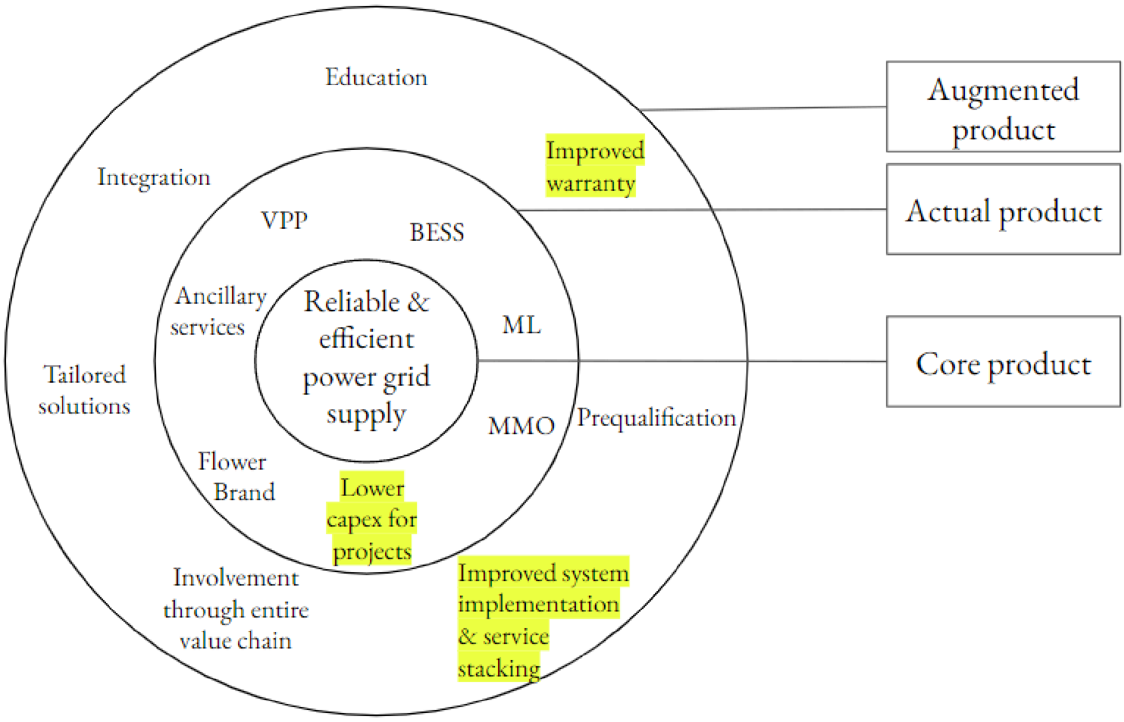

Figure 39 - Flower's future value proposition if they implement BESS development. The changes are highlighted.

6.4 RBV Analysis Used on the Case Company Future

With the case company's future scenarios now presented, this chapter aims to present the different capabilities that the implementation of each scenario might need. It will then end with an analysis of where the new capabilities will be placed on the VRIO model in every scenario.

6.4.1 Continue as Usual Scenario Capabilities

As discussed in section 6.2.1.1, Flower will continue its operations without the need to acquire resources and competencies specifically for BESS development. Instead, the focus will remain on utilising both existing and new resources and competencies to drive business growth. The new required resources and competencies for achieving success in this future scenario are presented below.

6.4.1.1 Continue as Usual Resources

In this scenario, the primary focus is on expanding the business. Given that value creation is realised by the available capacity of Flower's portfolio (Interviewee 9, 2024), and considering the rapid increase in battery storage in Sweden, enhancing the sales and project development team is a logical step. By doing so, Flower could sell and develop more projects, attract additional partners, and increase the available capacity in their portfolio. To facilitate this growth, larger offices are required alongside the restructuring of the organisation. Additionally, the restructuring process should focus on efficiently streamlining communication across various domains within the company. All the resources are found in Tables 16 & 17 below:

Table 16 - Table of Financial, Physical, Human and Organisational resources for the Continue as usual scenario

Financial	Physical	Human	Organisational
	Larger offices	More sales engineers More project developers	New communication to maintain effective communication

Table 17 - Table of dynamic, distinctive and threshold resources of Flower for the internal R&D scenario

Dynamic	Distinctive	Threshold
More sales engineers More project developers New communication to maintain effective communication		Larger offices

6.4.1.2 Continue as Usual Competencies

From the analysis carried out, the interviews conducted there are no new competencies that Flower will implement in this scenario.

6.4.2 Internal Research & Development Scenario Capabilities

As was described in the internal R&D (chapter 6.2.1.2) there would be several changes that would have to occur in order for Flower to create their own product. These costs would come in several new resources required, as well as, new competencies needing to be brought in. This part will give a summation of these capabilities.

6.4.2.1 Internal Research & Development Resources

Considering the resources required for an R&D attempt at Flower to develop their own BESS some resources are deemed more important than others. The major one would however be facilities to assemble as well as the knowledge of how a BESS system should be manufactured. This is a difficult subject to give precise answers to what is needed but the facility would need to be of a suitable size to contain everything needed to supply, assemble, store and export the batteries to where they are needed. For this Flower would need personnel to assemble the BESS as well as project leaders working at this facility.

In order to create a well-functioning product they would also need to create designs which would necessitate hiring in the form of an R&D department and bringing in several new employees. From the interviews, as well as, what knowledge could be obtained, some knowledge that is required here is people with power electronics-, electrochemistry-, electronics-, battery chemistry,- low-level programming languages-, electronic measurement- and battery cell market knowledge.

Some of these developments could be easier at Flower compared to their competitors since their development can be eased with investments in smaller systems first. This is due to Flower having the Flower hub that currently operates with control systems talking with their batteries which would lower the entry barriers, thus lowering the R&D costs. Another way that the company could lower their barriers is its earlier established fail-fast, learn-fast mentality that is something ingrained in the company. This would be an integral part of helping the employees have trust that their supervisors would support them in the development process.

With more facilities, there could also be increased communication difficulties which is something that the company currently isn't experiencing but is common for companies operating at multiple sites. A way of reducing these communication problems would therefore be necessary.

The major resource that would come about from this and a distinctive resource would be the BESS itself. This scenario would also provide the most knowledge about the BESS to be obtained at the company as everything would need to be obtained for someone at the company. This, however, is at the cost of the most investments needed.

Another major obstacle is the judicial process of a BESS to be approved and used which according to one interviewee is one of the biggest problems in the industry today (Interviewee 3, 2023). From this, some research was carried out and provided substantial evidence for this which is showcased in Appendix C. This is also something that the interviews pointed at as a big problem which perhaps isn't even possible to clear in the next 3 years (Interviewee 3, 2023).

Something that is also a major consideration is the complexity of the product which also has a major impact on the financial and competitive outcome of the system. This however is complex and as an economic outcome is not included in this thesis purpose this will not be included here but instead will be brought up in the discussion. Flower will also need to implement a risk management framework to identify, assess, and mitigate financial, technological, and market risks inherent in internal R&D projects.

If Flower decides to invest in its own system there would also need to be new supply chain channels or business networks established. Most of the battery cell manufacturers are currently Chinese and a quick introduction to the battery cell market was described in 4.3.3. As was described there, there are several bottlenecks currently in the value chain and these would not necessarily be lowered by assembling a BESS yourself but rather just altered from the old suppliers to the new ones. However, as you are now closer to the refineries and the battery cell market is experiencing rapid growth this could be changed looking into the future. Something here to consider is how the old business networks could be altered by Flower moving into the BESS development market. Most companies do not want to supply their competitors or do at least want to increase their costs in order to lower their market chances. This is especially worrying as this could impact the good relationship that Flower currently has with its suppliers.

Implementing a risk management framework is also seen as imperative to identify, assess, and mitigate financial, technological, and market risks inherent in contracted R&D projects. Additionally, Flower should formulate plans for gradually integrating internal R&D capabilities in the future, leveraging experiential learning and reducing reliance on outsourcing over time.

Table 18 - Table of Financial, Physical, Human and Organisational resources for the internal R&D scenario

Financial	Physical	Human	Organisational
Funding for e.g.: • R&D department • Assembly facility	BESS Larger offices New assembly site R&D equipment R&D facilities	Assembly workers More sales engineers More project developers R&D team consisting of e.g.: • BESS knowledge • Battery chemists • Electrochemistry Engineers • Electronics Engineers • Experts in the battery cell market • Low-level language specialised in programmers • Measurement engineers • Power electronics Engineers	Judicial Clearings IP IP management New assembly department New R&D department New communication channels New supplier relationships Risk management

Table 19 - Table of dynamic, distinctive and threshold resources of Flower for the internal R&D scenario

Dynamic	Distinctive	Threshold
New communication channels New supplier relationships Risk management Increased external transparency IP IP management Organisational business partner	BESS	Larger offices More sales engineers More project developers Funding for e.g.: • R&D department • Assembly facility R&D team consisting of e.g.: • BESS knowledge • Battery chemists • Electrochemistry Engineers • Electronics Engineers • Experts in the battery cell market • Low-level language specialised in programmers • Measurement engineers • Power electronics Engineers New assembly site R&D equipment R&D facilities

6.4.2.2 Internal Research & Development Competencies

When it comes to competencies Flower would mainly gain several new ones obtained by the increased knowledge from a BESS. There could also be improvements in their VPP and MMO as a greater knowledge of how the batteries operate could help them with optimising them for their trading. The greater control of BESS development would also ensure a higher degree of alignment of newer BESS with the company's overall business strategies, resulting in a product more suitable for their own value creation.

There could also be opportunities to sell the developed product resulting in new revenue streams for Flower moving into this market.

Table 20 - Table of dynamic, distinctive and threshold competencies of Flower for the internal R&D scenario

Dynamic	Distinctive	Threshold
	BESS development	

6.4.3 Joint Venture Scenario Capabilities

As was described in the segment joint venture in Chapter 6.2.1.3 the largest difference of Flower if they choose to implement a joint venture strategy is a larger reliance on a different partner. This would therefore create several new capabilities which would need to be implemented.

6.4.3.1 Joint Venture Resources

When moving into a joint venture, perhaps the most obvious consequence but often overlooked aspect is the establishment of a close business partner. In this, there come both benefits, as well as, drawbacks as this would provide new company resources in the form of joint venture knowledge, more network relationships and more financial means. This however comes with obligations depending on what form the joint venture takes and can therefore have an impact on Flowers's current resources.

As was described in Chapter 6.2.1.3 there would be a need for new communication channels between the two companies. There would also need to be some changes. Entering into a joint venture early has shown to impact for example the organisational structure and culture of the company, primarily through changing the management style and impacting human resources functions (Bingöl, D et Al., 2020) The organisational changes could have an impact on the company moving forward.

Another change is as described in the introduction of this case that joint venture often reduce the costs of entering into a new industry (Kamien, , Muller,& Zang, 1992; Barney, 2013). This is especially interesting for Flower as most interviewees answered that the primary reason for the theme to start developing a BESS would be if it reduced costs for them and thusly if the development costs can be reduced this makes the whole investment more desirable. (Interviewee 3, 2023; Interviewee 4, 2023; Interviewee 7, 2024; Interviewee 8, 2024; Interviewee 11, 2024, Interviewee 12, 2024)

Another change would be the need for increased transparency with outsider companies, this should however be easier at Flower as they're currently a company that works openly and often with transparency in the organisation.

Another aspect to take into account is that this scenario would probably lead to a split of the company from currently only being in one place to a company operating multiple offices. Their current location at the centre of Stockholm wouldn't suit itself to be a place to operate a manufacturing office for the BESS which would necessitate a second manufacturing site. This could impact the company in multiple ways. In order to evade silo thinking the company would need to better specify their business profile and culture to not lose it. Flower would also need to work more with the communication channels that they currently operate with as this would be paramount for operating at multiple sites. For this constant evaluation of the company culture would be needed and a constant revaluation of how the culture is and if there are problems between the different sites. Implementing a risk management framework would also be needed to identify, assess, and mitigate financial, technological, and market risks inherent in joint venture projects.

Along with this, a new distinctive resource can be seen. The integration of knowledge from a different company would create a BESS which could be better suited for Flowers's needs. This could for the ancillary service market be as the parameters described in Chapter 6.3.2.1 Also, there could be better communication channels inside the joint venture which was one of the problems described currently between Flower and their suppliers (Interviewee 12, 2024). In order to do this some more human resources would however be needed. Primarily, according to industry experts, there would be a need for power electronics engineers, electrochemistry engineers, electronics engineers, battery chemists, low-level language specialised programmers, measurement engineers, as well as, experts in the battery cell market.

In comparison with internal R&D, the establishment of a joint venture is often associated with lower R&D costs as it establishes knowledge sharing between the two companies. It's also a competitively lower financial strain due to the joint financials created by the two companies involved in a joint venture.

When it comes to the earlier described judicial hurdles it's hard to say how these could be impacted as they are highly reliable on what company Flower decides to create the joint venture with. It's however with the scenario described seen as a lower judicial hurdle compared to for example the internal R&D scenario

The implementation of a risk management framework is deemed essential to identify, evaluate, and address financial, technological, and market risks associated with contracted R&D projects. Furthermore, Flower should develop strategies for progressively incorporating internal R&D capabilities in the long term, utilising experiential learning, and gradually diminishing dependence on outsourcing.

If more comparisons with the internal R&D scenario can be made there would be some resources that would be introduced just as with that scenario. For example, as with the case of internal R&D, there would also need to be several new business networks established. There would be alterations in their current business connections, which would probably worsen the business connections that Flower currently has.

Table 21 - Table of Financial, Physical, Human and Organisational resources for the joint venture scenario

Financial	Physical	Human	Organisational
Funding for e.g.: • R&D department • Assembly facility	BESS Larger offices New assembly site R&D equipment R&D facilities	Assembly workers More sales engineers More project developers R&D team consisting of e.g.: • BESS knowledge • Battery chemists • Electrochemistry Engineers • Electronics Engineers • Experts in the battery cell market • Low-level language specialised in programmers • Measurement engineers • Power electronics Engineers	Changes in the organisational structure Greater degree of transparency to external companies IP IP management Judicial Clearings New assembly department New business partners New R&D department New communication channels New supplier relationships Offering shared control of the business Organisational business partner Risk management

Table 22 - Table of dynamic, distinctive and threshold resources of Flower for the joint venture scenario

Dynamic	Distinctive	Threshold
New communication channels New supplier relationships Funding Risk management Increased external transparency IP IP management Organisational business partner Greater degree of transparency to external companies Offering shared control of the business	BESS	BESS development knowledge Changes in the organisational structure Judicial clearings Strategic partnerships with relevant partners Funding for e.g.: ● R&D department ● Assembly facility Larger offices New assembly site R&D equipment R&D facilities Assembly workers More sales engineers More project developers R&D team consisting of e.g.: ● BESS knowledge ● Battery chemists ● Electrochemistry Engineers ● Electronics Engineers ● Experts in the battery cell market ● Low-level language specialised in programmers ● Measurement engineers ● Power electronics Engineers

6.4.3.2 Joint Venture Competencies

When it comes to competencies the main change that a joint venture would bring is the change from only being a single company to also being a joint venture. This would necessitate a more intense renewal of communications channels inside the company with the joint venture as well as a continual relationship with the partnered company. Otherwise, the analysis has shown that the same dynamic, distinctive and threshold competencies as with the internal R&D scenario would need to be established thus resulting in the following table:

Table 23 - Table of dynamic, distinctive and threshold competencies of Flower for the joint venture scenario

Dynamic	Distinctive	Threshold
Business connections with a partner	BESS development	

6.4.4 Mergers and Acquisitions Scenario Capabilities

In the section discussing technology licensing within the scenario presentations (Chapter 6.2.1.5), an introduction to what that scenario would look like was outlined. This Chapter will now describe what changes in resources and competencies this would lead to.

6.4.4.1 Mergers and Acquisitions Resources

The new resources gained are listed and categorised in the tables below. These are the same as in the case of a joint venture (see motivations in 6.3.3). However, one difference is the nature of the financial resources gained differs between a merger and an acquisition. In the case of a merger, additional financial resources can be gained, depending on the juridical agreements and synergies achieved. Similarly, in the case of an acquisition, the acquiring company may gain additional financial resources through access to the acquired company's assets, technology, or market share. Furthermore, Implementing a risk management framework is imperative to identify, assess, and mitigate financial, technological, and market risks. Additionally, Flower should formulate plans for gradually integrating internal R&D capabilities in the future, leveraging experiential learning and reducing reliance on outsourcing over time.

Table 24 - Table of Financial, Physical, Human and Organisational resources for the Mergers and Acquisition scenario

Financial	Physical	Human	Organisational
Funding for e.g.: • R&D department • Assembly facility	BESS Larger offices New assembly site R&D equipment R&D facilities	Assembly workers More sales engineers More project developers R&D team consisting of e.g.: • Battery chemists • Electrochemistry Engineers • Electronics Engineers • Experts in the battery cell market • Low-level language specialised in programmers • Measurement engineers • Power electronics Engineers	Changes in the organisational structure IP IP management Judicial Clearings New assembly department New R&D department New communication channels New supplier relationships Risk management

Table 25 - Table of dynamic, distinctive and threshold resources of Flower for the Mergers and Acquisition scenario

Dynamic	Distinctive	Threshold
Changes in the organisational structure IP IP management New communication channels	BESS	Funding for e.g.: • R&D department • Assembly facility Larger offices Judicial Clearings New assembly department New assembly site New R&D department New supplier relationships Risk management R&D equipment R&D facilities

6.4.4.2 Merger and Acquisition Competencies

New competencies are those gained from the M&A, i.e. competencies that the target company holds. However, one competence Flower would need to develop, in order to minimise the risk of cultural clashes, is a procedure to integrate the acquired company's culture seamlessly into its existing organisational framework.

Table 26 - Table of dynamic, distinctive and threshold competencies of Flower in a Mergers and Acquisition scenario

Dynamic	Distinctive	Threshold
	BESS Knowledge	

6.4.5 Technology licensing Scenario Capabilities

As was described in the segment technology licensing in Chapter 6.2.1.5 the use case would provide several new resources and competencies that would be integrated into the company. This Chapter aims to display these changes.

6.4.5.1 Licensing Resources

The first major resource that the use of licensing would lead to is the contractual arrangement which would also entail a close business partner. This could also, just as with the partners in the other scenarios, be used as a knowledge entryway to gain more knowledge about the BESS process. However, not to the extent of M&A, joint venture or internal R&D. With the benefit that Flower would not have to pay as much as licensing is usually attributed to lower costs.

The licensing scenario would also provide Flower with a BESS much like the other scenarios. Some caveats with this is however that they would not be as involved with the development process of the product. This could lead to a battery that is less suitable for Flowers' needs and thus not as much control over what the development process would look like.

There would be needs for compensation up to some extent, this deal is hard to speculate in but there would probably be a lower return on gains. If Flower then decides to sell the batteries themselves they would create a new market just as in the earlier scenarios where Flower developed their own BESS but this would also be at a lower return. This would also be the case for Flower using the batteries themselves.

As motivated in earlier scenarios, Flower will also need to implement a risk management framework in this scenario.

A major benefit of this process is that there would be substantially lower judicial obstacles as compared to the internal R&D scenario as the batteries would not have to go through the same amount of testing when they are already developed. There would however be some judicial boundaries with the assembly and testing of the batteries developed.

Just as with the earlier described Chapters, there would also be some overlapping resources required with the same reasoning as the earlier scenarios. These being:

- ➢ New communication channels
- ➢ New business partners
- ➢ Lesser degree of control and a higher degree of transparency
- ➢ Having to expand into getting a manufacturing/assembly site
- ➢ A new supplier network would need to be established.

Table 27 - Table of Financial, Physical, Human and Organisational resources for the Technology licensing scenario

Financial	Physical	Human	Organisational
Funding for e.g.: ● Assembly facility	BESS Larger offices New assembly site	Assembly workers More sales engineers More project developers	Judicial Clearings New assembly department New communication channels New supplier relationships Risk management Strategic partnerships with relevant partners

Table 28 - Table of dynamic, distinctive and threshold resources of Flower for the Technology licensing scenario

Dynamic	Distinctive	Threshold
New communication channels New supplier relationships Risk management Strategic partnerships with relevant partners Structure to support gradually integrating internal R&D	BESS	Assembly workers Funding for e.g.: ● Assembly facility Larger offices Judicial Clearings More sales engineers More project developer New assembly department New assembly sites R&D team consisting of e.g.: ● Battery chemists ● Electrochemistry Engineers ● Electronics Engineers ● Experts in the battery cell market ● Low-level language specialised in programmers ● Measurement engineers ● Power electronics Engineers

6.4.5.2 Licensing Competences

In much the same way as with the earlier scenarios there would also be some changes in the competencies of the company. However, there would be less of a focus of knowledge expansion which would result in the following competencies:

Table 29 - Table of dynamic, distinctive and threshold competencies of Flower in the Technology licensing scenario

Dynamic	Distinctive	Threshold
Business connections with a partner	BESS Knowledge	

6.4.6 Contracted out R&D Scenario Capabilities

As was described in Chapter 6.2.1.5 the use case would provide several new resources and competencies that would be integrated into the company. This chapter aims to display these changes.

6.4.6.1 Contracted out R&D resources

Flower will require substantial financial resources to allocate funds for contracted R&D, covering expenses such as hiring external firms, consultants, experts, equipment, and facilities. Investments are also needed to acquire more efficient tools for communication and collaboration.

Additionally, Flower needs to dedicate time and effort to identify and establish collaborations based on expertise, track record, and alignment with Flower's objectives, developing strategic partnerships with external firms specialised in BESS R&D. Robust intellectual property management protocols must be developed to define ownership rights, confidentiality agreements, and patent filing strategies to safeguard Flower's innovations and proprietary information. As a result of this, there will be IPs that will provide entry barriers for future competitors.

Establishing a risk management framework is also crucial for recognizing, evaluating, and mitigating the financial, technological, and market risks inherent in contracted R&D projects. Additionally, Flower should strategize for the gradual integration of internal R&D capabilities over time, relying on experiential learning and reducing dependence on outsourcing.

Table 30 - Table of Financial, Physical, Human and Organisational resources of Flower with Contracted out R&D

Financial	Physical	Human	Organisational
Funding for external R&D initiatives Funding for e.g.: • R&D department • Assembly facility	BESS Larger offices New assembly site R&D equipment R&D facilities	Assembly workers More sales engineers More project developers Consultants & Experts in • Battery chemistry • Electrochemistry • Electronics • The battery cell market • Low-level languages • Measurement for electronics • Power electronics	Judicial Clearing IP IP management New assembly department New R&D department New communication channels New supplier relationships Risk management Strategic partnerships with relevant partners Structure to support gradually integrating internal R&D

Table 31 - Table of dynamic, distinctive and threshold resources of Flower with Contracted out R&D

Dynamic	Distinctive	Threshold
IP New department New communication channels New R&D department New supplier relationships Risk management Strategic partnerships with relevant partners Structure to support gradually integrating internal R&D	BESS	Assembly workers Consultants & Experts in ● Battery chemistry ● Electrochemistry ● Electronics ● The battery cell market ● Low-level languages ● Measurement for electronics ● Power electronics Funding for external R&D initiatives Funding for e.g.: ● R&D department ● Assembly facility Judicial Clearing Larger offices More sales engineers More project developers New assembly department New assembly site R&D equipment R&D facilities

6.4.6.2 Contracted out R&D Competences

Just as in other scenarios, this scenario entails forging new business connections and also acquiring more BESS knowledge.

Table 32- Table of dynamic, distinctive and threshold competencies of Flower with Contracted out R&D

Dynamic	Distinctive	Threshold
Business connections with a partner	BESS Knowledge	

6.4.7 Summary of New Capabilities Identified

In order to simplify for the reader a summary of all of the capabilities have been composed from chapter 6.4.1-6 in the 3 tables below:

Table 33 - Summary of Financial, Physical, Human and Organisational resources in every future scenario

Financial	Physical	Human	Organisational
Funding for e.g.: • R&D department • Assembly facility Funding for external R&D initiatives	BESS Larger offices New manufacturing/assembly site R&D equipment R&D facilities	Assembly workers More project developers More sales engineers R&D team consisting of e.g.: • Battery chemistry • Electrochemistry • Electronics • The battery cell market • Low-level languages • Measurement for electronics • Power electronics	Judicial Clearings New communication channels New communication to maintain effective communication New department New supplier relationships Risk management Strategic partnerships with relevant partners Structure to support gradually integrating internal R&D

Table 34 - Summary of dynamic, distinctive and threshold resources in every future scenario

Dynamic	Distinctive	Threshold
Evaluation of communication within the company Funding Increased external transparency IP IP management More project developers More sales engineers New communication channels New communication to maintain effective communication New supplier relationships Organisational business partner Risk management Risk management Risk management Strategic partnerships with relevant partners Structure to support gradually integrating internal R&D	BESS	Assembly site Assembly workers BESS development knowledge Changes in the organisational structure Consultants & Experts in Intellectual property Funding for external R&D initiatives Judicial clearings Larger offices New department New manufacturing/assembly site R&D equipment R&D facilities R&D team

Table 35 - Table of dynamic, distinctive and threshold competencies in every future scenario

Dynamic	Distinctive	Threshold
Business connections with a partner	BESS Knowledge	R&D Knowledge

6.4.8 VRIO Analysis of the Future Scenarios

Now that the new capabilities have been identified, there is considerable overlap among them. To illustrate the impact of these new capabilities, a VRIO analysis has been conducted similarly to Chapter 5.3.5. However, to avoid repetition, the following chapter has been divided into tables presenting the information in the following manner:

➢ In section 6.4.8.1, the capabilities introduced from the "Continue as usual" scenario that will impact every scenario are outlined in Table 36.
➢ In section 6.4.8.2, overlapping capabilities are grouped and presented in Table 37, to avoid analysis of overlapping capabilities.
➢ In section 6.4.8.3, a VRIO analysis on the new capabilities was performed which is illustrated in Table 38.

Something that also needs to be mentioned here is that all of the capabilities that were in the current analysis (chapter 5.3) would still be present in the company in all of the future scenarios. However, if it's not mentioned, there would not be any changes in the placement of that capability.

6.4.8.1 VRIO of the Continue as Usual Scenario

The Continue as usual scenarios provided several interesting capabilities that Flower will need in order to head into the future. To start off as they are currently in an expansion state there is a need for everyone to fit in and the current offices do not provide ample space. Therefore the larger offices will provide value but as offices can't be considered rare the following parameters are ranked as false. These new offices will however force Flower to get new communication channels that they will also have to work with continually to maintain the same good communication as today. This is therefore also ranked as valuable but as the communication channels will be the same as used by competitors these can't be ranked as rare. Following this is the need for more sales engineers. These are also perceived as valuable as they will contribute to more sales being done by the business but as there are plenty of sales engineers these can't be ranked as rare. Lastly, the need for more project developers is also something that came up plenty of times but as the company is expanding. This is ranked in the same way as more sales engineers with the same reasoning behind it. This concludes the rankings and is summed up in Table 36 below.

Table 36 - Table of capabilities in the Continue as usual scenario and their ranking in with the VRIO model

Capability	V	R	I	O
Larger offices	TRUE	FALSE	FALSE	FALSE
More sales engineers	TRUE	FALSE	FALSE	FALSE
More project developers	TRUE	FALSE	FALSE	FALSE
New communication to maintain effective communication	TRUE	FALSE	FALSE	FALSE

6.4.8.2 Groupings of the Future Scenarios with BESS Development

Before conducting the VRIO analysis in the next section soe grouping is seen as necessary as some capabilities were deemed as overlapping. These groupings are presented in Table 37 below.

Table 37 - Table of future capabilities in scenarios, Internal R&D, Joint venture, Merger and acquisition Technology licensing, Contracted out R&D and how they're grouped in this thesis

Capability	Groupings
Assembly site	New manufacturing site
Assembly workers/team	Changes in the organisational structure, New department,
BESS	
BESS development knowledge	
Communication	Evaluation of communication within the company, Increased external transparency, New communication channels, Restructuring in order to streamline communication
Funding	R&D department, Assembly facility
Judicial Clearings	
Larger offices	
More project developers	
More sale engineers	
New supplier relationships	
R&D team	Changes in the organisational structure, New department, R&D team consisting of e.g.: BESS knowledge Battery chemists Electrochemistry Engineers Electronics Engineers Experts in the battery cell market Low-level language specialised in programmers Measurement engineers Power electronics Engineers
IP	
IP Management	
Risk Management	

6.4.8.3 VRIO of the Future Scenarios with BESS Development

For the scenarios including BESS development, all the new capabilities were listed and analysed with the VRIO model (see table 38).

First and foremost, an assembly site and team are necessary for the development of BESS. These capabilities are valuable but not considered rare, as they are easy to acquire. Other capabilities that only check the V box include communication, funding, larger offices, more project developers, an R&D team, and risk management. All of these are considered valuable in each scenario which includes BESS development. This is motivated by the fact that each scenario characterises a situation in which Flower expands and grows its business, not only its current business model but also venture into something new, in this case, BESS development. In the long perspective, Flower is deemed as taking full control over its own R&D, which is why an R&D team needs to be established now already, regardless of which scenario Flower chooses. As all of these capabilities are deemed essential for these scenarios and are relatively uncomplicated to acquire, none of them are considered to check the R box.

For a BESS to be approved and used effectively, it needs to go through a lot of judicial clearings (see more in Appendix C), and thus this capability checks both the V and R boxes. This capability is also considered to be costly to imitate, thus it also checks the I box. Interviewee 3 (2023) stated that juridical clearings are in fact a challenging problem, and perhaps aren't possible to fulfil in only three years.

BESS is one of the capabilities that checks V, R, I, and O. Thus ranking it as a capability that gives sustainable competitive advantage. A well-functioning BESS is not only valuable and rare but also very costly to imitate - both expensive and time-consuming. And since these scenarios cover situations where Flower restructures its organisation we also consider that the company will be organised in a way to fully exploit this competitive advantage.

As seen in Table 38, BESS development knowledge checks the first two boxes. However, regarding the I and O boxes, it depends on the scenario. For the scenarios Technology Licensing and Contracted Out R&D, this capability would not check the I box, because the knowledge is held by external partners instead of Flower, making it hard to motivate that the knowledge could not be bought by another competitor. Thus making it imitable enough to make it false.

Regarding IP (intellectual property) and IP management, the ranking according to the VRIO model also depends on the scenarios. For the scenario of Technology licensing, these two capabilities are not considered valuable for Flower, as they wouldn't need to design a new system but would rather rely on what someone else has developed. Otherwise, the IP for the other scenarios will check the boxes V, R, and I. This is because IPs are considered valuable when developing new products, and furthermore, the complex nature of a BESS makes this capability rare and costly to imitate. However, since Flower is not familiar with R&D in this sphere of products, the company will most likely not be structured in a way to gain full competitive advantage from this capability. For all scenarios that check the V, R, and I boxes, the IP management capability will be considered valuable for the respective scenario. The reason for this is that IP management is considered valuable in every company that possesses intellectual property. For this very reason it is also considered to not be rare, thus only checking the V box.

Table 38 - Table of future capabilities which are overlapping between the future scenarios where a BESS should be developed and their ranking in with the VRIO model

Capability	V	R	I	O
Assembly site	TRUE	FALSE	FALSE	FALSE
Assembly workers/team	TRUE	FALSE	FALSE	FALSE
BESS	TRUE	TRUE	TRUE	TRUE
BESS development knowledge	TRUE	TRUE	Depends on scenario	
Business connections with a partner	Depends on scenario			
Communication	TRUE	FALSE	FALSE	FALSE
Funding	TRUE	FALSE	FALSE	FALSE
Judicial Clearings	TRUE	TRUE	TRUE	FALSE
Larger offices	TRUE	FALSE	FALSE	FALSE
More project developers	TRUE	FALSE	FALSE	FALSE
More sale engineers	TRUE	FALSE	FALSE	FALSE
New supplier relationships	TRUE	FALSE	FALSE	FALSE
R&D team	TRUE	FALSE	FALSE	FALSE
IP	Depends on scenario			
IP Management	Depends on scenario			

6.5 Future Technology Strategy

The future technology strategy of Flower is highly dependent on what acquisition method is used as the way in which technology acquisition is used creates the fundamentals of how the scenarios will be implemented. With this said, this chapter only provides the feedback loops of how technology acquisition will transpire back into what capabilities Flower will need depending on the different scenarios with a small change between the different scenarios. The interviews primarily provided information that Flower is satisfied with their technology acquisition methods today and that they aren't planning on changing them if it's not deemed as more cost-efficient. This means that there won't be that many changes in comparison to Chapter 5.5 except that with the implementation of the BESS, a change in the characterization of that technology would be needed. This change would mean that in some scenarios (Internal R&D, Joint venture, Merger and acquisition) the BESS would be placed as a distinctive technology, while in the other scenarios implementing a BESS (Technology Licensing and contracted out R&D) it would be placed as a basic technology. This is a result of how great of a distinct advantage Flower themselves will be able to get if they implement that scenario.

6.6 Summary of Future Scenarios

To summarise what has been discussed in Chapter 6 a recall of how the framework is supposed to be used is in order. The framework gives a view of both the static of where the company is and the dynamics of how the company will change going into the future.

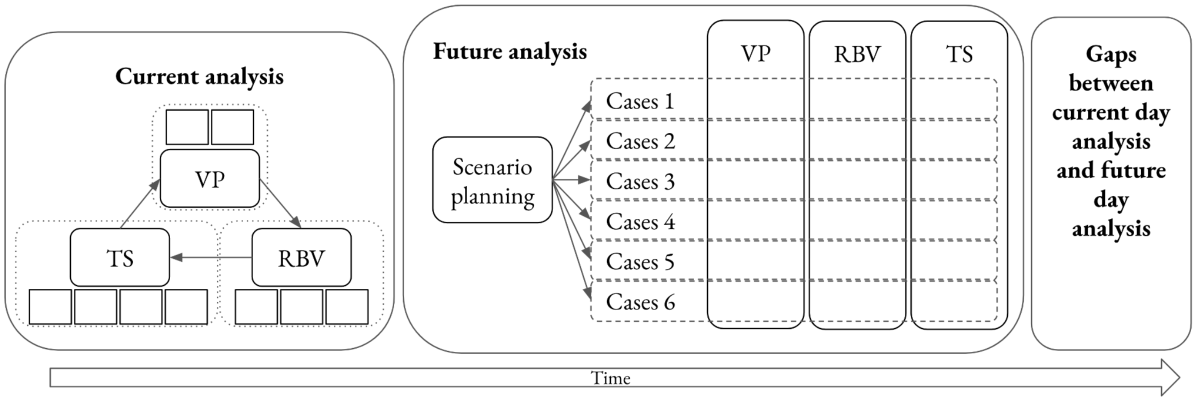

Figure 3 - Overview of how the 3 theories will be used in the current and future analysis

This chapter therefore started by introducing the 6 future scenarios that have been deemed of interest to this thesis. These are derived from Davenport's article concerning technology acquisition, as well as a Continue as usual scenario, to evaluate what types of changes the BESS would introduce. A summary of these cases is showcased below:

1. Continue as usual - Flower continues to buy a BESS from external suppliers
2. Internal R&D - Flower develops a BESS through internal R&D.
3. Joint venture - Flower develops a BESS through the usage of a partnered company.
4. Merger and acquisition - Flower develops a BESS by buying another company.
5. Technology licensing - Flower develops a BESS by buying a licence from another company and assembling the necessary parts themselves.
6. Contracted out R&D - Flower develops a BESS through consultants and uses their help to start their R&D department.

From the analysis carried out in Chapter 6, some changes have been perceived in the 6 different scenarios. Five of them implemented BESS and one did not. This produced two alternative future value propositions where one was with the inclusion of the BESS development and one was with the exclusion of it. Only a handful of changes from the current value proposition were found in this analysis. In both the alternatives an improved service stacking is something that everyone can expect from Flower going into the future regardless of the scenario. If a BESS were to be developed by the company there could be more improvements in the form of lower CapEx for projects and an improved warranty. However, these two aspects are not seen as self-evident and would require further analysis. A showcase of what the two alternatives would lead to is provided in the two figures below:

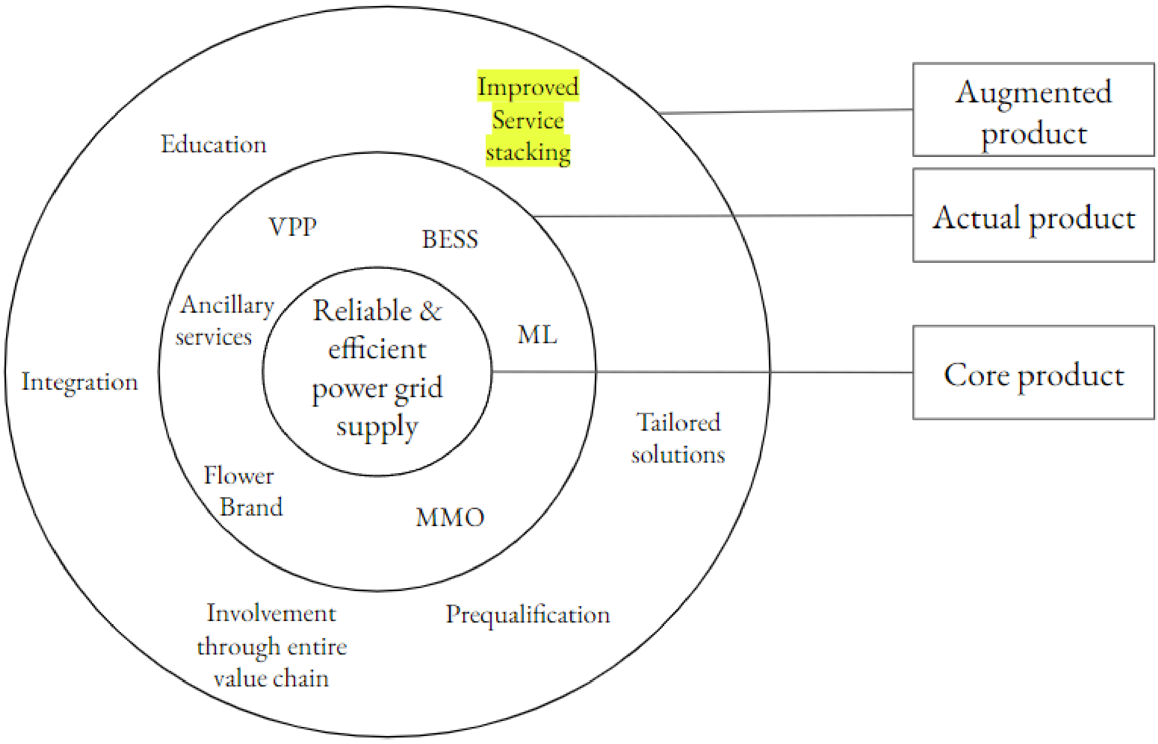

Figure 38 - Future value proposition in lines with "Continue as usual scenario". The one change is improving the service stacking feature. The change is highlighted.

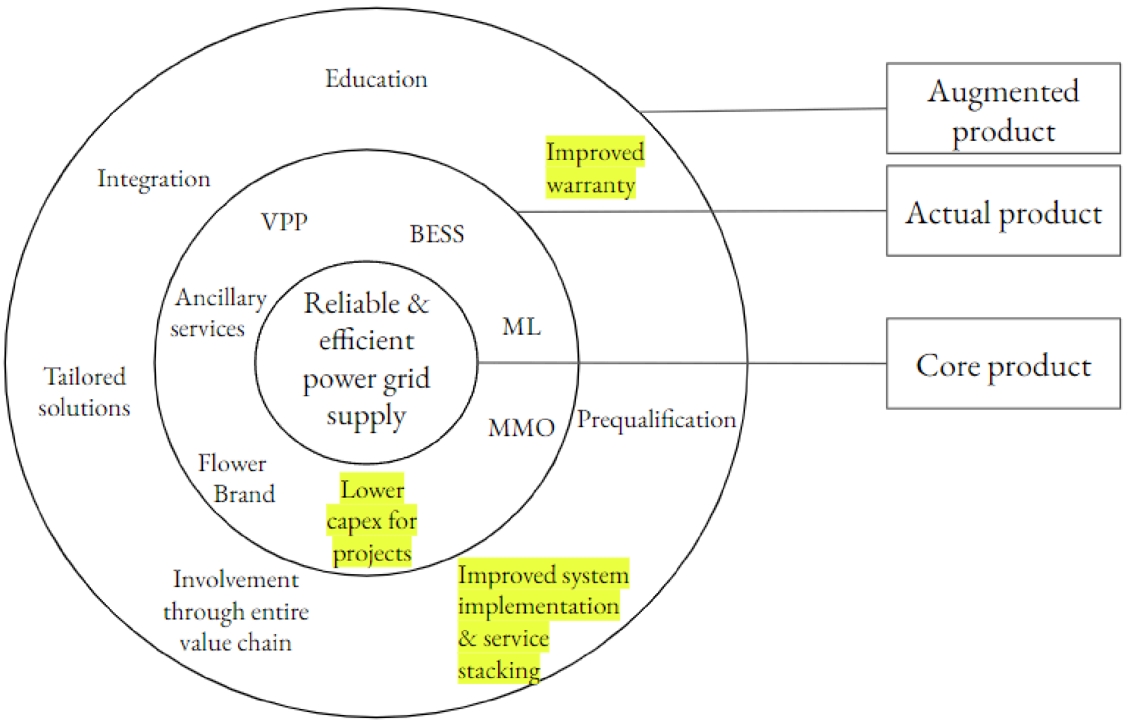

Figure 39 - Flower's future value proposition if they implement BESS development. The changes are highlighted.

After this, an analysis of what capabilities would be needed in the different scenarios was carried out. In these scenarios, a pattern was found where in the first scenario, Continue as usual, Flower didn't need as many capabilities as the other scenarios. This is because the integration of a BESS development and assembly department would necessitate the introduction of new capabilities. When it comes to the other scenarios, some capabilities were seen as more or less necessary and most of the capabilities were overlapping but with more or less of an impact, for example, every scenario needed funding as a resource, however, the amount is dependent on the scenario. A summation of all of the different capabilities found is showcased in the tables below:

Table 33 - Summary of Financial, Physical, Human and Organisational resources in the future scenarios

Financial	Physical	Human	Organisational
Continue as usual			
	Larger offices	More sales engineers More project developers	New communication channels
Internal R&D			
Funding for e.g.: • R&D department • Assembly facility	BESS Larger offices New assembly site R&D equipment R&D facilities	Assembly workers More sales engineers More project developers R&D team consisting of e.g.: • BESS knowledge • Battery chemists • Electrochemistry Engineers • Electronics Engineers • Experts in the battery cell market • Low-level language specialised in programmers • Measurement engineers • Power electronics Engineers	Judicial Clearings IP IP management New assembly department New R&D department New communication channels New supplier relationships Risk management
Joint Venture			
Funding for e.g.: • R&D department • Assembly facility	BESS Larger offices New assembly site R&D equipment R&D facilities	Assembly workers More sales engineers More project developers R&D team consisting of e.g.: • BESS knowledge • Battery chemists • Electrochemistry Engineers • Electronics Engineers • Experts in the battery cell market • Low-level language specialised in programmers • Measurement engineers	Changes in the organisational structure Greater degree of transparency to external companies IP IP management Judicial Clearings New assembly department New business partners New R&D department New communication channels

<table>
<tr><td></td><td></td><td>Power electronics Engineers</td><td>New supplier relationships
Offering shared control of the business
Organisational business partner
Risk management</td></tr>
<tr><td colspan="4">Mergers and acquisition</td></tr>
<tr><td>Funding for e.g.:
R&D department
Assembly facility</td><td>BESS
Larger offices
New assembly site
R&D equipment
R&D facilities</td><td>Assembly workers
More sales engineers
More project developers
R&D team consisting of e.g.:
Battery chemists
Electrochemistry Engineers
Electronics Engineers
Experts in the battery cell market
Low-level language specialised in programmers
Measurement engineers
Power electronics Engineers</td><td>Changes in the organisational structure
IP
IP management
Judicial Clearings
New assembly department
New R&D department
New communication channels
New supplier relationships
Risk management</td></tr>
<tr><td colspan="4">Technology licensing</td></tr>
<tr><td>Funding for e.g.:
Assembly facility</td><td>BESS
Larger offices
New assembly site</td><td>Assembly workers
More sales engineers
More project developers</td><td>Judicial Clearings
New assembly department
New communication channels
New supplier relationships
Risk management
Strategic partnerships with relevant partners</td></tr>
<tr><td colspan="4">Contracted our R&D</td></tr>
<tr><td>Funding for external R&D initiatives
Funding for e.g.:
R&D department
Assembly facility</td><td>BESS
Larger offices
New assembly site
R&D equipment
R&D facilities</td><td>Assembly workers
More sales engineers
More project developers
Consultants & Experts in
Battery chemistry
Electrochemistry
Electronics
The battery cell market
Low-level languages
Measurement for electronics
Power electronics</td><td>Judicial Clearing
IP
IP management
New assembly department
New R&D department
New communication channels
New supplier relationships
Risk management
Strategic partnerships with relevant partners
Structure to support gradually integrating internal R&D</td></tr>
</table>

Table 34 - Summary of dynamic, distinctive and threshold resources in the future scenarios

Dynamic	Distinctive	Threshold
Continue as usual		
New communication channels		More sales engineers More project developers Larger offices
Internal R&D		
New communication channels New supplier relationships¨' Risk management Increased external transparency IP IP management Organisational business partner	BESS	Larger offices More sales engineers More project developers Funding for e.g.: • R&D department • Assembly facility R&D team consisting of e.g.: • BESS knowledge • Battery chemists • Electrochemistry Engineers • Electronics Engineers • Experts in the battery cell market • Low-level language specialised in programmers • Measurement engineers • Power electronics Engineers New assembly site R&D equipment R&D facilities
Joint Venture		
New communication channels New supplier relationships¨' Funding Risk management Increased external transparency IP IP management Organisational business partner Greater degree of transparency to external companies Offering shared control of the business	BESS	BESS development knowledge Changes in the organisational structure Judicial clearings Strategic partnerships with relevant partners Funding for e.g.: • R&D department • Assembly facility Larger offices New assembly site R&D equipment R&D facilities Assembly workers More sales engineers More project developers

		R&D team consisting of e.g.: • BESS knowledge • Battery chemists • Electrochemistry Engineers • Electronics Engineers • Experts in the battery cell market • Low-level language specialised in programmers • Measurement engineers • Power electronics Engineers
Mergers and acquisition		
Changes in the organisational structure IP IP management New communication channels	BESS	Funding for e.g.: • R&D department • Assembly facility Larger offices Judicial Clearings New assembly department New assembly site New R&D department New supplier relationships Risk management R&D equipment R&D facilities
Technology licensing		
New communication channels New supplier relationships Risk management Strategic partnerships with relevant partners Structure to support gradually integrating internal R&D	BESS	Assembly workers Funding for e.g.: • Assembly facility Larger offices Judicial Clearings More sales engineers More project developer New assembly department New assembly sites R&D team consisting of e.g.: • Battery chemists • Electrochemistry Engineers • Electronics Engineers • Experts in the battery cell market • Low-level language specialised in programmers • Measurement engineers • Power electronics Engineers

Contracted our R&D		
IP New department New communication channels New R&D department New supplier relationships Risk management Strategic partnerships with relevant partners Structure to support gradually integrating internal R&D	BESS	Assembly workers Consultants & Experts in • Battery chemistry • Electrochemistry • Electronics • The battery cell market • Low-level languages • Measurement for electronics • Power electronics Funding for external R&D initiatives Funding for e.g.: • R&D department • Assembly facility Judicial Clearing Larger offices More sales engineers More project developers New assembly department New assembly site R&D equipment R&D facilities

Table 35 - Table of dynamic, distinctive and threshold competences in the future scenarios

Dynamic	Distinctive	Threshold
Continue as Usual		
Internal R&D		
	BESS development	
Joint Venture		
Business connections with a partner	BESS development	
Merger and acquisition		
	BESS Knowledge	
Technology licensing		
Business connections with a partner	BESS Knowledge	
Contracted out R&D		
Business connections with a partner	BESS Knowledge	

With the capabilities now summarised, a VRIO analysis was carried out which resulted in some conclusions. Four of the capabilities were found to have an impact on all of the scenarios, them being the same as the ones in the Continue as usual scenario. None of these capabilities will have a larger impact than giving Flower competitive parity. The other five scenarios will have an assortment of other capabilities impacting the company. Most of these resources are the same, however, some depend on the scenario and will be further elaborated on in Chapter 7. In this VRIO analysis, only one capability was seen as leading to a full competitive advantage, that capability being the BESS resource. A table showcasing all of the capabilities and the VRIO analysis is showcased in the two tables below:

Table 39 - Table of capabilities in the all senarios and their placement in the VRIO model

Capability	**V**	**R**	**I**	**O**
Larger offices	TRUE	FALSE	FALSE	FALSE
More sales engineers	TRUE	FALSE	FALSE	FALSE
More project developers	TRUE	FALSE	FALSE	FALSE
New communication to maintain effective communication	TRUE	FALSE	FALSE	FALSE

Table 40 - Table of future capabilities which are overlapping between the future scenarios where a BESS would be developed and their placement in the VRIO model

Capability	**V**	**R**	**I**	**O**
Assembly site	TRUE	FALSE	FALSE	FALSE
Assembly workers/team	TRUE	FALSE	FALSE	FALSE
BESS	TRUE	TRUE	TRUE	TRUE
BESS development knowledge	TRUE	TRUE	Depends on scenario	
Business connections with a partner	Depends on scenario			
Communication	TRUE	FALSE	FALSE	FALSE
Funding	TRUE	FALSE	FALSE	FALSE
Judicial Clearings	TRUE	TRUE	TRUE	FALSE
Larger offices	TRUE	FALSE	FALSE	FALSE
More project developers	TRUE	FALSE	FALSE	FALSE
More sale engineers	TRUE	FALSE	FALSE	FALSE
New supplier relationships	TRUE	FALSE	FALSE	FALSE
R&D team	TRUE	FALSE	FALSE	FALSE
IP	Depends on scenario			
IP Management	Depends on scenario			

Finally, for the Technology strategy aspect, there would, just as with the value proposition, barely be any changes if a BESS was implemented. The only one that has been found from the analysis is that in the scenarios of Internal R&D, Joint venture, Merger and acquisition, a BESS would be categorised as a distinctive technology while in the Continue as usual, Technology Licensing, Contracted out R&D scenarios it would continue being a basic technology.

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7. **Analysis,** Gaps Between Today and the Future

This chapter presents what changes each scenario would entail and provides an overview of how great of a difference each identified change would make. An analysis of these is also conducted and presented.

7.1 Introduction

As a result of the previous chapter some gaps have been found between how Flower is operating today and how it will operate when operating in different scenarios. As a result of this, this chapter will analyse the changes between Chapter 6, the future day analysis, in comparison to Chapter 5, the current analysis. This is to find out what changes the different scenarios would lead to. This chapter is therefore an analysis of the empiricism and analysis presented in the earlier described chapters. To present these in an easily digested manner it has been split up into the same sections as the earlier chapters with the changes in capabilities presented in chapter 7.2. The changes in the value proposition are in chapter 7.3 and finally, the changes in the future technology strategy are presented in the last chapter.

7.2 Value Proposition Gaps

As outlined in Chapter 6.3, there aren't significant differences between the future value proposition and the current value proposition. Building upon and enhancing its current service stacking is something Flower will do in all scenarios. There are indications that various implementations of BESS development will further improve service stacking. However, these indications are not definitive, and no examples have been found.

Implementing BESS development would, in addition to improving service stacking, also enhance the overall system implementation. One result of Flower developing its own BESS is that it can offer better guarantees, in case something malfunctions. Another outcome is that by developing its own BESS, it can lower the total CapEx cost of the projects being undertaken. However, whether there will be a lower CapEx on the projects is not certain. This is something mentioned by the interviewees, but no research has been conducted on it. If CapEx does decrease in the scenarios implementing BESS development, there may be reasons to proceed with one of those scenarios.

To summarise, the consequences of implementing BESS development for the value proposition are considered small. The biggest potential consequence is a lower CapEx for the projects; however, this needs to be examined more deeply.

7.3 Capabilities Gaps

As was seen in chapter 6.3, several new capabilities will have to be formed if Flower chooses to implement a BESS or not. This has resulted in the following 16 capabilities that will have impact on Flower heading into the future:

- Assembly site
- Assembly workers/team
- BESS
- BESS development knowledge
- Communication
- Funding
- IP
- IP Management
- Judicial Clearings
- Larger offices
- More project developers
- More sales engineers
- New communication to maintain effective communication
- New supplier relationships
- R&D team
- Risk management

Some of these are depending on what type of scenario they are in as well as how great of an impact these would have. Therefore, the chapter has been split up into two parts. The capabilities that were deemed to only depend on if a BESS is implemented and the capabilities that would have changed between different scenarios.

7.3.1 Gaps Formed by Capabilities that Will Not Differ Depending on the Scenarios

Four capabilities were deemed as having an impact on every scenario, and these are the following:

- Larger offices
- More sales engineers
- More project developers
- New communication channels to maintain effective communication.

The VRIO analysis concluded that all these capabilities only contribute to competitive parity. None of them are considered rare enough to confer a competitive advantage over competitors. Additionally, these capabilities are viewed as cost-effective, requiring no implementation of new capabilities into the company. Consequently, the gaps between these capabilities are perceived as small and align with the natural expansions of the company's scale-up trajectory.

7.3.2 Gaps Formed by Capabilities that Will Have a Differing Impact Depending on the Scenarios

To start off, the capabilities that were deemed as only having a change if a BESS was implemented or not. The requirement for an assembly site and assembly workers or team was determined to be necessary only if Flower implements BESS development. The number of workers and site(s) are deemed to be the same in every implementation of a BESS as the different scenarios do not take into account future expansions.

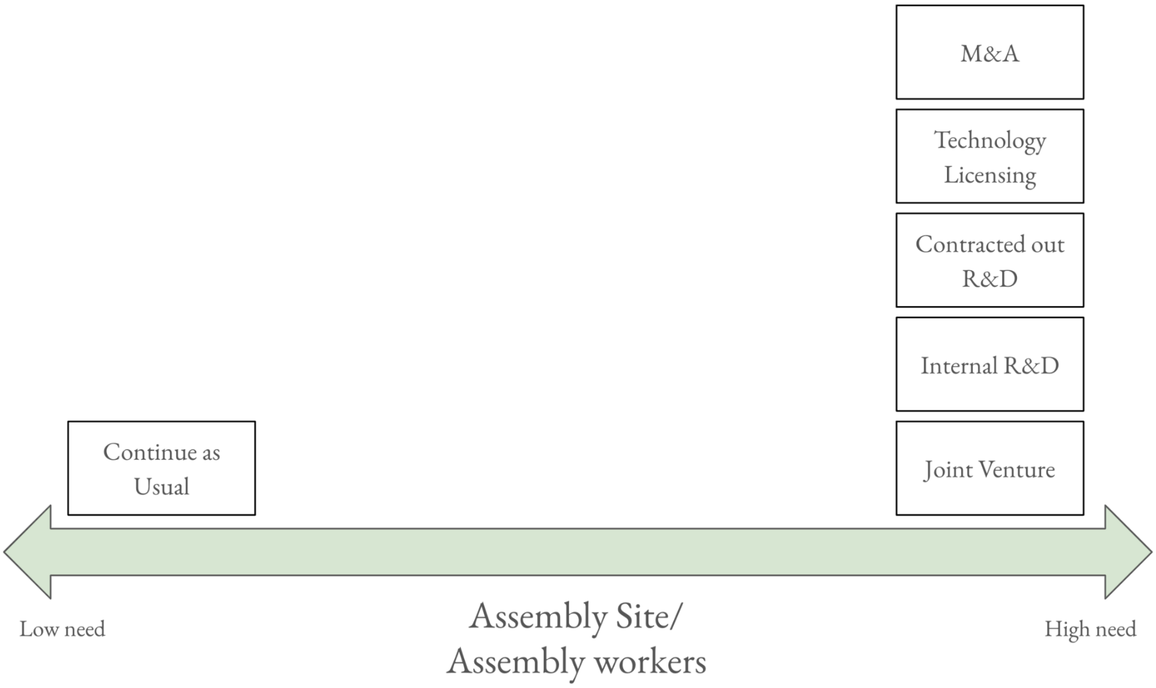

Figure 40 - Ranking of the Assembly site/Assembly workers needed in the future scenarios

When it comes to the functionality of a future BESS the scenarios are deemed to be much more differing. To start, the Continue as usual scenario provides a lot of uncertainties. It does not give the same amount of power to Flower to decide what types of BESS should be developed. It relies heavily on the types of BESSs another firm wants to develop, therefore there might be misalignments going into the future on what type of BESS Flower wants to make in comparison with their suppliers. This therefore provides no changes from the current situation. Next, Technology licensing is deemed to provide more power to Flower concerning them being able to decide what type of BESS they want and how to build it with the integration of assembly into Flower. However, just as with the Continue as usual scenario, there might be differing opinions on what type of BESS should be designed. Contracted out R&D is ranked much like the Technology licencing, however, this scenario provides Flower with a larger control of the design process of the BESS. The Merger and acquisition scenario is ranked in the same way as the Joint Venture scenario since both of these rely heavily on what other companies have developed and therefore it's hard to rank them against each other. What can however be said is that the design process would reach a higher amount of integration into Flower and to the VPP which would provide a higher amount of ability to design the product towards Flower's needs. Finally, the Internal R&D scenario provides Flower with full control of every aspect of the design and assembly of the product. This enables them to fully design the product that they want, thus making them able to fully change and design the BESS functionality. However, they would still be limited by the manufacturer's battery cell design.

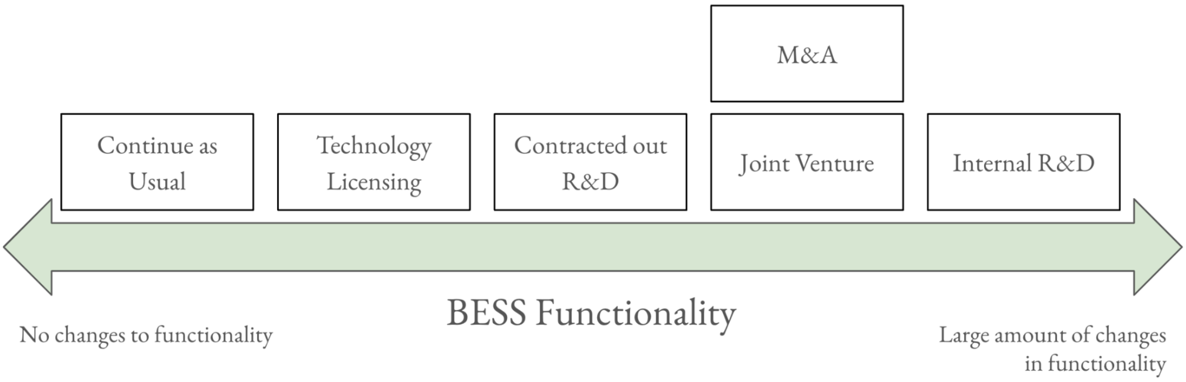

Figure 41 - Rankings of BESS functionality changes in the different scenarios

The next capability is BESS knowledge. This aspect is heavily dependent on the extent of the R&D team, therefore, these two capabilities are ranked together. To constitute this a small recap of what BESS knowledge consists of is primarily knowledge of:

- ➢ Battery chemistry
- ➢ Component knowledge
- ➢ Design of the system
- ➢ Electrochemistry
- ➢ Electronics
- ➢ Manufacturing of the BESS
- ➢ The battery cell market
- ➢ Low-level programming languages
- ➢ Measurement for electronics
- ➢ Power electronics

To start off, the continue as usual scenario does not require any R&D team which would constitute a very low amount of new knowledge acquisition in any of these aspects as Flower would not need to know about the BESS itself, only what suppliers they need to have. This is not to say that no new knowledge can be acquired, just that there are fewer incentives for knowledge gathering and therefore Flower would probably not gain as much. In the other scenarios where a BESS development is implemented, however, a lot more knowledge would be acquired. For example, the Technology licensing scenario provides much more information on what components are used, how they should be assembled and what the outcome of the implementation would be. This would however not give as much knowledge about the designs of the BESS as they would not take part in that process. In the Contracted out R&D, the consultants would be able to jumpstart this aspect of the knowledge gathering and integrate some of their knowledge into Flower. They would however leave after a while which makes Flower unable to gain and retain as much knowledge as in the Mergers and acquisition, Joint venture or Internal R&D scenario. This would therefore hamper the amount of knowledge acquired in the future due to the fact of the revolving evolution of technology acquisition. The last three scenarios, Mergers and acquisition, Joint venture and Internal R&D all lead up towards the highest amount of knowledge acquisition. This since in all three scenarios Flower would be enabled to learn about every aspect of knowledge needed to design, manufacture and produce a BESS and also retain the knowledge for future improvements.

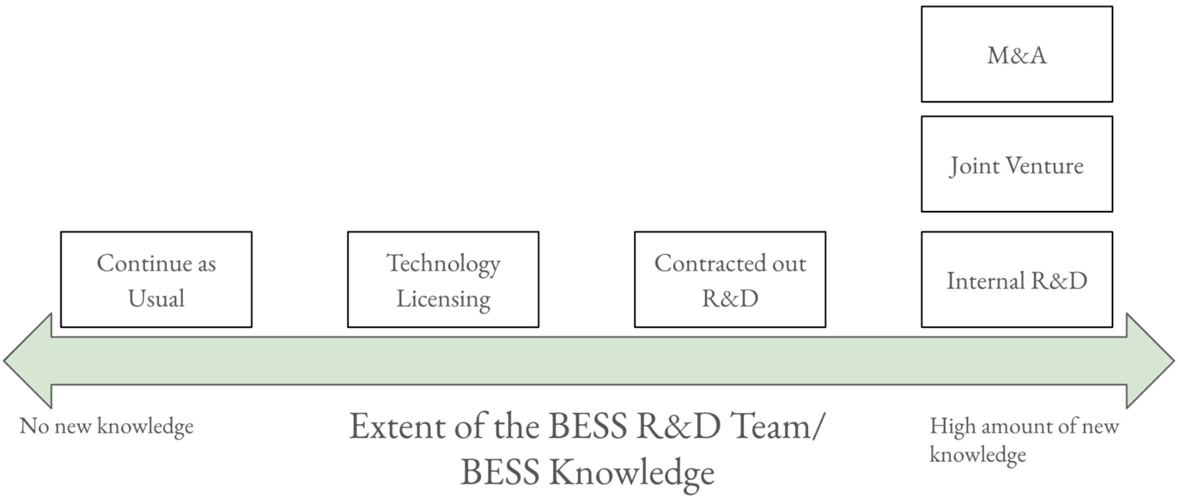

Figure 42 - Rankings of BExtent of the BESS R&D Team / BESS knowledge in the different scenarios

Communication changes will be needed in every scenario. In the Continue as usual scenario, the focus is on expanding the business. The consequences of this are the need for more and larger offices, as well as, more personnel. As this expansion is expected to develop rapidly, communication changes within the company, across different teams and offices, are needed to enhance efficiency. This is also true for the other five scenarios that implement BESS development. However, these five scenarios will require additional changes to accommodate, for example, additional external partners, new suppliers, and a new R&D domain. For this reason, these five scenarios are placed on the same level.

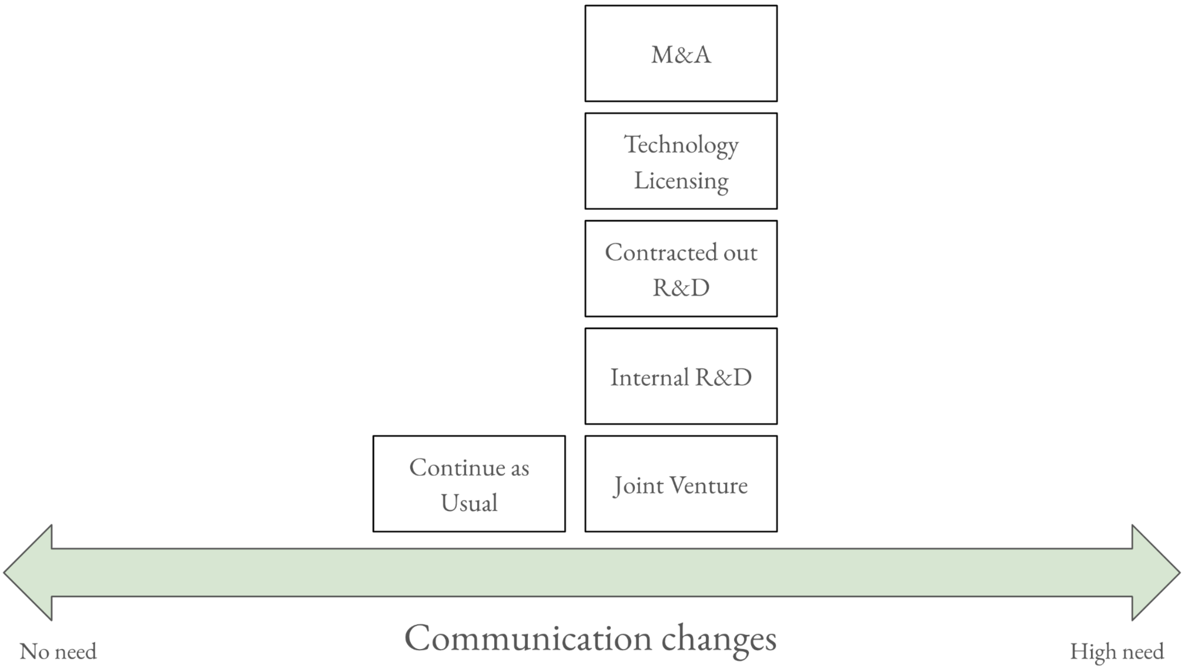

Figure 43 - Rankings of communication changes needed in the different scenarios

When it comes to financial investments needed there are large uncertainties between the scenarios. However, from the empiricism provided in earlier chapters, some things can be said. Firstly, the Continue as usual scenario does not necessitate a development of assembly or R&D for the BESS. The other scenarios would however need the same expansions as the Continue as usual scenario. Therefore the Continue as usual scenario is ranked as having the lowest need for financial investments. When it comes to Technology licensing, this scenario would require more financial investments, primarily in the assembly of the battery, however, there would be no need for an R&D department which places this scenario next to the Continue as usual scenario. Something that however needs to be said here is that the need for investments does not overlap with the lower returns that can be expected if profit sharing is implemented with their licensee. The Joint venture scenario is the scenario with perhaps the largest amount of uncertainty. This since the companies which Flower partners with may or may not have either an assembly part or an R&D department. However, as there might be a need for these departments, the financial investment placement is higher than for Technology licensing. Contracted out R&D would necessitate the need for an assembly department which places it higher on the financial investment scale. In the Merger and acquisition scenario, there are also a lot of uncertainties. These are highly dependent on whether Flower chooses to merge with or acquire another company. If they choose to merge, the financial investments needed would be highly dependent on what company Flower chooses to merge with. Therefore the merger scenario is highly overlapping with the joint venture scenario. On the acquisition side, however, a lot of investments would be needed to fully acquire another company. There could also be further needs for investments if the company acquired does not control the whole value chain needed for developing a BESS. Therefore it's placed in the space for second highest financial investments. Finally, internal R&D would necessitate the build-up of every part of a value chain and knowledge acquisition of every part in the development and assembly of the BESS. This therefore places it as the scenario with the highest need for financial investments.

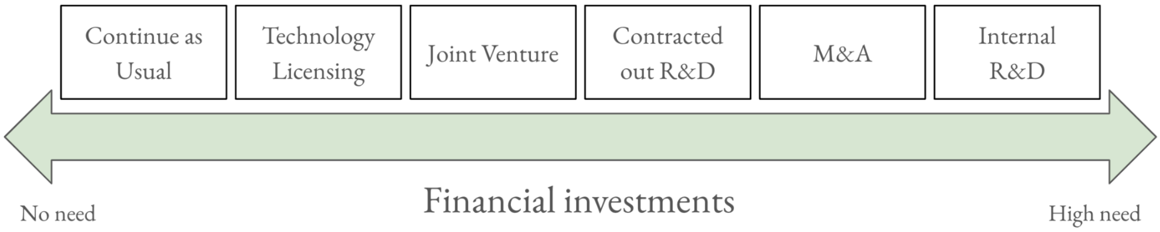

Figure 44 - Rankings of Financial investments needed in the different scenarios

For the Continue as usual scenario there is no BESS development, and thus IPs, IP management, and judicial clearings regarding BESS will not be needed. Therefore these capabilities are ranked as having no need for further IP /IP management or judicial clearings concerning BESS in the continue as usual scenario. For Internal R&D, the need for this capability will be the highest as Flower themselves will need to manage their IPs and also obtain all necessary judicial clearances. For Contracted out R&D this need is somewhat lower. Flower will still need to go through these processes themselves, but a lot of the knowledge related to that will come from the externally hired consultants. However, Flower will learn from the consultants and over time start doing this themselves. In the scenarios of M&A and Joint Venture, these capabilities will be held by the target company that Flower acquires or creates an alliance with. Consequently, the need for Flower to incorporate these capabilities into their organisation is considered to be even lower compared to Internal and Contracted out R&D. Lastly, there is the Technology Licensing scenario. In this case, IP management and judicial clearances will already be handled by the company from which Flower licences the technology. However, as the company licensing their technology has obtained clearances primarily for licensing purposes, Flower will likely need additional clearances to use their final BESS product effectively. Thus this is ranked higher than the Continue as usual scenario.

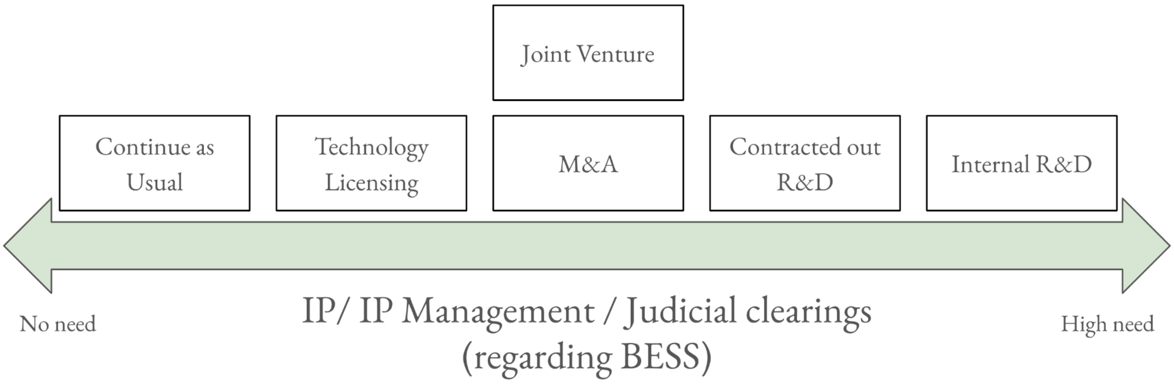

Figure 45 - Rankings of the IP / IP Management/ Judicial clearings needed in the different scenarios

The Continue as usual scenario accounts for the fact that Flower is currently satisfied with their suppliers and will continue to use them; it does not necessitate the need for any new suppliers. Every other scenario, however, would necessitate new value chains of components, primarily from large exporters in China, and therefore changes in the supplier network. This would result in a large amount of new suppliers being needed in every scenario except Continue as usual. Further still, in the Technology licensing and Contracted out R&D scenarios, there would also be extra suppliers needed in the form of technology acquisition suppliers. This places these two scenarios as the two with the highest number of new suppliers in comparison with the other scenarios.

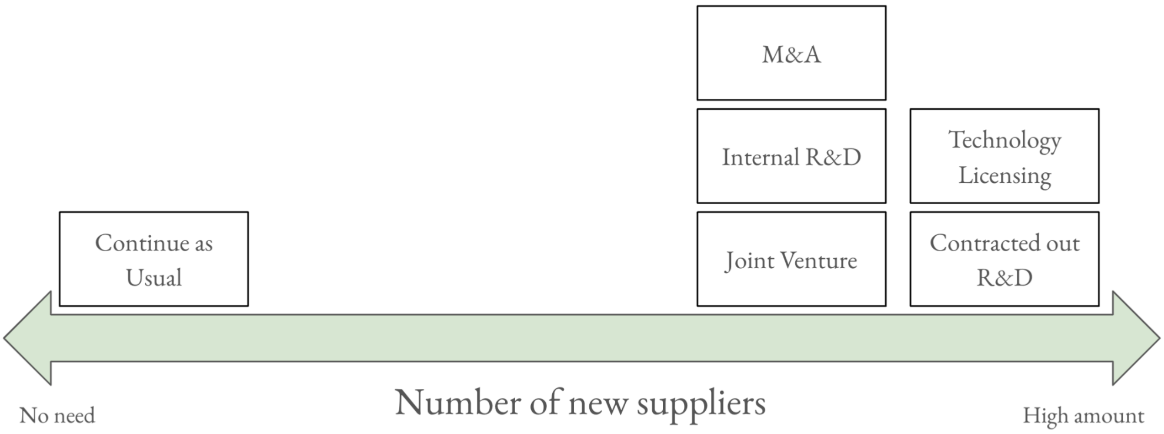

Figure 46 - Rankings of the number of new suppliers needed in the different scenarios

Risk management is imperative when dealing with new business areas, especially those requiring significant funding. Given that this is the case for every scenario in which Flower develops its own BESS, there is a high need for implementing risk management frameworks to identify, assess, and mitigate financial, technological, and market risks.

Therefore, all scenarios, except Continue as usual, are ranked with the highest need for implementing risk management. In the Continue as usual scenario, this capability is ranked the lowest, with the motivation that Flower already has a risk management system in place for their existing business and will not require a new one.

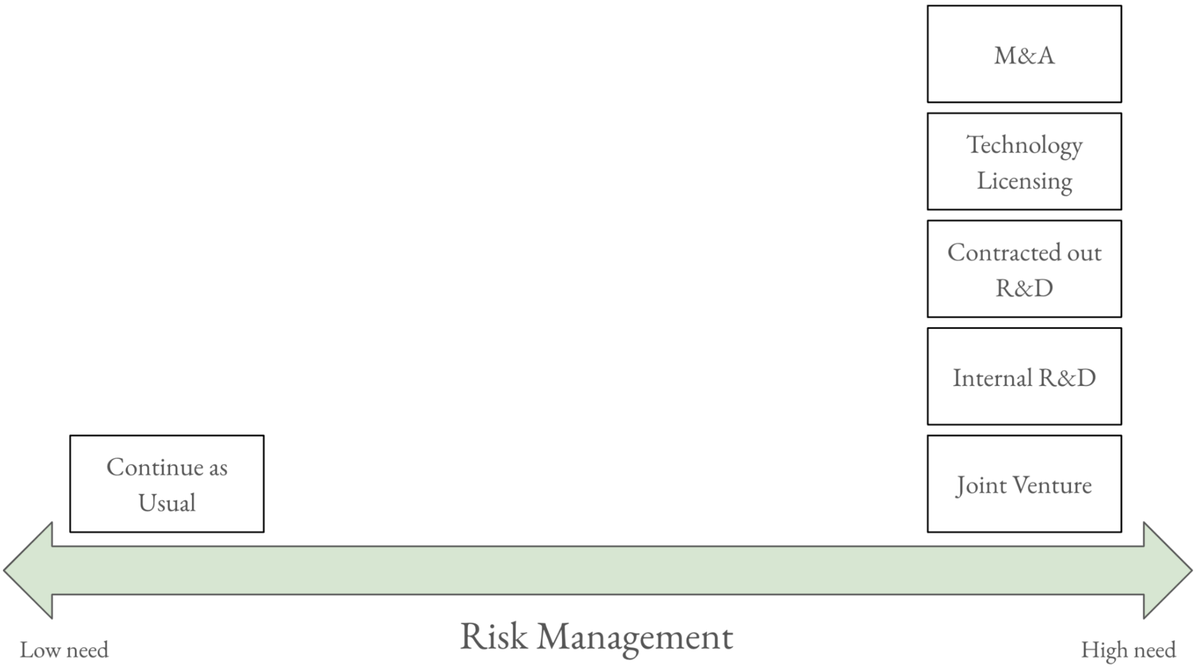

Figure 47 - Rankings of the need for risk management in the different scenarios

7.4 Future Technology Strategy Gaps

When it comes to the technology strategy that the company is going to implement it is highly dependent on the different scenarios since the scenarios choose which method is used. Therefore the value proposition and capabilities needed should be used in conjunction to realise what type of technology acquisition is best suited for Flower. In Flower's case, the capabilities needed are deemed as rather big in comparison to the additions in the value proposition. Therefore, the benefits are considered to be seen as rather small.

The only changes in the technology categorisations are deemed to be the change of BESS from an external technology to either a basic technology in the Technology licensing and Contracted R&D scenarios or a distinctive technology in the Internal R&D, Joint venture and Merger and acquisition scenarios. This is primarily because the three scenarios last mentioned are deemed to lead to more distinctive advantages which could provide more competitive advantages. However, this is at the cost of much larger costs of implementation.

Flower now needs to take this information and decide on which scenario they should go for. This thesis will provide them with more information and will hopefully assist them in their decision moving forward

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8. Conclusions

This chapter showcases and presents the conclusions that can be made from the empiricism and analysis made in earlier chapters.

As can be recalled the purpose of this thesis was to "*...to describe the development of high-tech services in the energy sector in Sweden by analysing the consequences of technology acquisition and knowledge basis in companies.* " To do this an analysis of a case company has provided valuable insights on what aspects need to be evaluated to conclude the best way moving forward.

To describe the development of high-tech services a case company has in this thesis been described and the considerations that the company has to make have been proposed. This has been done through the use of our proposed framework which was applied in a scenario analysis. In this analysis, different consequences of each scenario have been analysed and these scenarios have also been juxtaposed by the case company continuing in the same manner as they are currently doing to compare what changes each scenario would entail.

To evaluate this the value proposition changes that the implementation of a BESS would provide have been showcased. This is primarily the potential of lower CapEx of projects, the potential of warranty and potential service stacking.

This however comes at the cost of 16 new capabilities which will be needed to be implemented depending on the scenarios. These capabilities are highly dependent on which acquisition method is used which has been explored in the scenarios proposed. There have also been 4 additional capabilities that each scenario is going to need, that can be seen as the necessity for Flower moving forward in their scale-up phase. Therefore, the conclusion can be said to be that the development of high-tech services in the energy sector consists of high resources gatherings for low value additions.

As has been proposed, in Flower's case, the capabilities needed are deemed as rather big in comparison to the additions in the value proposition. Therefore, the benefits of implementing BESS development are considered to be rather small.

9. Discussions

This chapter contains a discussion of the limitations of the thesis created. It also provides a discussion about the future improvements of the methodology, as well as, what future work was deemed to be of interest from this thesis.

9.1 Limitations in the thesis:

Some extra risks weren't brought forth in the report but were discussed internally. For example, the risks of creating a suboptimal BESS containing a BMS that wouldn't be good enough could lead to a malfunctioning unit. This could lead to everything from small problems with the unit to a major cascade error prompted by a unit catching fire, and spreading to adjacent units. It's easy to see that the problems here are widespread and that it's hard to say anything about how great the risks are or how great they could be without a risk assessment.

A problem with the methodology used in this thesis has been the heavy reliance on one case company. This lowers the validity of the case as it can't be concluded that the conclusions solely rely on the case company's unique situation.

When looking at the scenarios picked, every scenario consists of several sub-scenarios which were forced to be left out due to (1) the size of the thesis and (2) the problems of including too many scenarios presented by Lindgren and Bandhold (2009) in Chapter 3.6. This, however, made some plausible scenarios pop up which could be interesting for future research, For example:

- ➢ Partnerships as a potential future scenario wasn't picked as it was deemed as too big of a step for the company as they still wanted to be their own company with their own business structure. A different case company with a different business model would therefore be interesting to compare to Flower. However, for a different case company, this could be interesting to evaluate.
- ➢ Group Venture, that is a joint venture that consists of more than one company, was something that often came up in articles and was also often cited as under-evaluated. As this increases the complexity of the constellation more information was needed than was available to be gathered for this thesis. However, when looking into the future of research, a more fleshed-out analysis of this constellation could also be of interest to future works.

Another problem has been the format of a master's thesis due to the publication of it. As the conclusions and results will be provided in an open environment, much empiricism has been redacted as either the people interviewed or the company didn't want the empiricism published.

9.2 Future improvements of the methodology

Some potentially valuable extensions to the methodology, which, if the authors had the opportunity for a revision, would be considered, involve greater engagement at the case company sites. Currently, the analysis presented in this thesis is solely conducted by the authors, who, using both empirical data and the outlined framework, assess the case company's current situation and potential future scenarios. An intriguing enhancement to this approach would involve greater involvement with the company. One example of this which was discussed was organising a workshop with the interviewees. In this workshop, relevant frameworks would be introduced, and the personnel would be encouraged to conduct their independent analyses of the case company. Following this individual analysis, a second round of discussion would be facilitated, during which the thesis writers would present their findings. This interactive process could lead to a subsequent round of analysis where additional insights and information could be gleaned through collaborative exploration.

An interesting expansion of the framework used in this thesis would be the inclusion of a customer satisfaction model or a bigger analysis of what it is that the customer wants from Flower products. From this a more thorough analysis of what the benefits would be and also an attempt to evaluate how these changes would change the desirability of the product.

9.3 Contribution of Knowledge

9.3.1 Contribution to the Academy

This master's thesis contributes to the academic community by introducing a new proposed framework that integrates theories on Value Proposition, Resource-Based View (RBV), Technology Strategy, and Technology Life Cycle (TLC). The proposed framework serves as a tool for developing high-tech services in the energy industry in Sweden. Importantly, there are no constraints to this framework, suggesting its applicability to other industries as well. Furthermore, the gap analysis conducted in Chapter 7, has provided insights on how the RBV interacts with the value proposition.

9.3.2 Contribution to the Case Company

For the case company, this work has contributed by conducting a fundamental investigation, resulting in information about the considerations the case company needs to make before potentially developing a BESS. With this information, the company can make a decision regarding which direction to pursue, thereby creating opportunities for further work within the chosen path forward.

9.3.3 Contribution to the Industry

This research contributes to the industry through its analysis of the considerations and decision-making processes involved in implementing BESS development within the energy sector. By offering insights into strategic alliances, technological procurement strategies, and key development considerations, this study provides valuable guidance to industry stakeholders seeking to navigate the complexities of the energy storage market. Through its findings, this research aims to advance industry practices and facilitate collaboration among industry players, ultimately contributing to the growth and sustainability of the energy industry.

9.4 Future Work

An interesting aspect that emerged during the industry analysis is the heavy reliance of the entire Western world on Chinese businesses in the BESS market in their value chain. While analysing the industry's landscape, it became apparent that every identifiable supplier depends on battery cells which are, to a large degree, manufactured within China. This dependency is increasing as the global shift toward electrification, a transition that is notably facilitated by innovations like the development of BESS, continues. This of course raises questions about how external political interests might wield influence over the Swedish market. Consequently, there is a need for a more in-depth analysis to propose strategic measures for controlling these dependencies. One avenue to explore is whether increased economic incentives could be strategically deployed to gain more control over these critical value chains, thereby mitigating potential risks associated with external political vulnerabilities. Another might be if there are larger players, like the EU or US who might instead expand their manufacturing of these products. All in all, this is an interesting geopolitical and economic question which will heavily affect what the energy industry, as well as, the electrification of Sweden will look like going into the future.

The presented work is currently grounded in hypothetical future scenarios. Nevertheless, this underscores the necessity of evaluating these scenarios in the future. Hence, a retrospective examination of the work after a few years could be deemed essential.

While the TAIDA framework has effectively presented the scenarios, it does not address the implementation of these different scenarios. The onus is now on the case company to decide which scenario to pursue and therefore implement the I, D and A parts of the framework.

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Appendix A. interview template

Interview template for market expert

Info:

Info om oss

Info om vårt examensarbete - Presentera att vi mest bryr oss om BMS för batterier i elnätet
undersöker utveckling av hightech tjänster i energisektorn
vi har ett fallföretag, flower, som vill utveckla BMS.

Får vi spela in samtalet?

Intervjun kan vara konfidentiell om du vill

Vi förväntar oss att det kommer tar ungefär 1h, men det är ok att bara stoppa när han vill

Efter arbetet skickar vi en transkribering där du får säga om något inte bör nämnas utanför. Vi kommer säga samma sak till dig

Inledande frågor:

1. Vill du kort introducera dig själva

2. Vad gör du idag?

3. Vad är din expertis inom BMS? Har du jobbat inom det?

4. Vill du kortfattat beskriva din bild av vad ett BMS är och vad det används till?

Frågor kring tekniken:

5. Vilka funktioner anser du att ett BMS måste ha?

6. Vad är det enligt dig som gör ett BMS bra eller mindre bra?

7. Vilka variabler är det som är viktiga i ett BMS? (SoC, SoH, temperaturmätningar...)

8. Ett BMS system som används i elnätet, ställs det inför andra utmaningar än det som ställs inom t.ex. elbilsbranschen?

9. Hur anpassade är olika BMS system mot batterierna? Har man ett system fungerar det för flera olika leverantörers batterier?

10. Vilka aspekter av BMS system skulle du säga att man som utomstående inte tänker på när man pratar om funktionerna av ett BMS?

11. Vet du om det finns några regulatoriska eller juridiska krav kring BMS?

12. Vad behöver man göra löpande för att underhålla ett BMS?

Frågor kring utveckling av BMS:

13. Vilka interna resurser, inklusive personalens expertis och utbildning, skulle du säga krävs för att utveckla ett BMS internt?

14. Finns det några potentiella dolda kostnader eller oförutsedda utmaningar som organisationer ofta stöter på när de försöker utveckla ett BMS?

15. Har du och kan du ge oss några av dina insikter angående den totala ägandekostnaden för ett BMS? (Har du några insiktier i vad som skapar kostnader när man utvecklar ett BMS? Är det t.ex. uteveckling, underhållet, personalen vs systeminköp? osv.)

16. Skulle du säga att det finns några problem som kan uppstå med att utveckla ett BMS system? Är några vanligare? (Hur ska man jobba för att minska dessa?)

17. I din erfarenhet vilka är de största komplikationerna som uppstår när man utvecklar ett BMS?

18. Har du sett eller hört om att något företag har skjutit sig i foten när dem försökte utveckla ett BMS? Varför hände det?

19. Från din erfarenhet, hur har tidslinjerna för att utveckla ett BMS sett ut?

Frågor kring marknaden:

20. Skulle du säga att det finns några specifika branschstandarder som är svåra att ta reda på men som man måste veta om? (Alltså inte krav men saker som är förväntade inom branchen)

21. Finns det några framväxande trender eller utvecklingar inom BMS som vi bör vara medvetna om?

22. Hur mogen skulle du säga att BMS teknologin är idag? (Sker konstanta förbättring, revulotionerande delar)

23. Finns det några krav från industrin om när man ska använda ett BMS system?

24. Kan du ge exempel på företag som själva utvecklat ett BMS?

25. Utav dessa företag, anser du att någon har varit mer eller mindre framgångsrik eller har ett bättre system, varför?

Extrafrågor om tid finns:

Skulle du säga att det kan finns potentiella geopolitiska eller globala faktorer som vi borde ha i åtanke när vi beslutar om man ska utveckla internt eller köpa externt?

(Hur skalbar är tekniken och kan den anpassa sig till framtida tillväxt och förändringar i vår verksamhet? Hur fungerar det med skalbarhet i BMS?

(Vilken är möjligheten till anpassning med denna teknik om vi utvecklar den internt och hur jämför den sig med en köpt lösning?

Avslutande frågor (När det är 5 min kvar):

26. Känner du att det är något mer kring BMS som vi inte har tagit upp där du kan ge oss råd eller överväganden?

27. Har du några tips på kunskapskanaler/böcker eller annat som vi kan använda för att fördjupa oss mer inom BMS?

28. Känner du till fler människor som jobbar med BMS system som vi också skulle kunna höra av oss till för att öka trovärdigheten på vår rapport?

29. Har du några frågor till oss?

Tack från oss!

Swedish interview template for the first round of interviews at Flower:

Info:

Info om oss
Vilka vi är lite snabbt, och berätta att vi håller "inledande" intervjuer för att få en bättre helhetsbild på organisationen och allt däremellan.

Info om vårt examensarbete - Presentera att vi mest bryr oss om BMS för batterier i elnätet
Syftet med vår rapport är att beskriva och analysera utvecklingen av high-tech tjänster i Sveriges energisektor - varav vi kommer att fokusera på Flower och en eventuell utveckling av BMS för batterier i elnätet.

Får vi spela in samtalet?

Intervjun kan vara konfidentiell om du vill

Vi förväntar oss att det kommer ta ungefär 1 timme

Efter arbetet skickar vi en transkribering där du får säga om något inte bör nämnas utanför. Vi kommer säga samma sak till dig

Inledande frågor:

1. Vill du kort introducera dig själva

2. Vad är det du gör på Flower?

Frågor om BESS

3. Vilka är funktionalitetskrav när ni avgör om ni ska använda batterier? (VA? MW? MWh? Responstid? osv.)

4. Vilka andra avgöranden är viktiga för er för att få rätt funktionalitet? (t.ex. är det något som ni anser är viktigt för de batterierna ni ska använda så som pris, möjlighet till leverans, hög kalender-livslängd eller något helt annat?)

5. Vad är det enligt dig som gör ett BESS bra eller mindre bra?

6. Anser du att något ni velat ha i era BESS har saknats när ni har köpt in dem?

7. I vårt arbete har vi mest undersökt Li-Ion batterier. Men många konkurrerande företag väljer alternativa system. Är endast Li-Ion batterier intressanta för er eller är andra BESS lösningar också det?

Frågor om BMS

8. Vad är det enligt dig som gör ett BMS bra eller mindre bra?

9. Vilka aspekter av BMS system skulle du säga att man som utomstående inte tänker på när man pratar om funktionerna av ett BMS?

10. Vad ser du för fördelar med att utveckla ert egna BMS?

11. Hur genomför ni i dagsläget kontroller av batteriets SoC, SoH. (Använder ni endast algoritmer? Genomför ni löpande kalibreringar av dessa algoritmer?)

Frågor kring teknikkunskaper på Flower:

12. Vad skulle du säga är de teknologier och kunskaper som mer fundamentalt er verksamhet baseras på?

13. Hur utvecklades dessa teknologier, skapade ni dem själva eller köpte ni in dem?

14. Anser du att ni har all den tekniska kompetens ni vill ha som bolag idag,

15. Vilka områden anser du att ni borde bli bättre inom?

16. Vilka interna resurser, till exempel personalens expertis och utbildning, skulle du säga krävs för att utveckla ett BMS internt?

17. Vilka av dessa kunskaper skulle du säga att ni har idag?

Frågor kring leverantörer

18. Vilka leverantörer har ni varit i kontakt med fram tills nu?

19. Hur beskriver ni erat samarbete med era batterileverantörer? (Är det en nära och öppen relation?)

20. Är batterileverantörerna flexibla och hjälpsamma när det gäller att anpassa sina lösningar efter era behov?

21. Vad skulle ni önska mer från era leverantörer i dagsläget?

Extra Frågor om tid finns:

Avslutande frågor (När det är 5 min kvar):

22. Känner du att det är något mer som vi inte har tagit upp och som du vill lyfta?

23. Har du några frågor till oss?

Tack från oss!

English interview template for the first round at Flower:

Informtion:

Information about us

Briefly who we are and mention that we conduct "introductory" interviews to gain a better overall understanding of the organization and everything in between.

Information about our thesis project

The purpose of this study is to describe and analyse the development of high-tech services and the consequences for the technology acquisition in a company within the energy sector in Sweden.

Can we record the conversation?

We expect it to take approximately 60 minutes, but feel free to let us know if you need to go anytime

All questions are entirely voluntary, so if you prefer not to answer something, feel free to let us know.

Afterward, we'll send a transcription where you can indicate if there's anything that should not be mentioned outside the interview

Introductory questions:

1. Would you like to briefly introduce yourself and what you currently do at Flower?

General questions about the company:

2. Can you briefly describe Flower, its mission, and its core values?

3. What are Flower's main products/services?

4. What would you describe as the company's biggest strengths currently?

5. What would you describe as your weaknesses at the moment? (Would you say that Flower faces any specific challenges? Are there any specific challenges related to internal resources and how they are best utilized?)

6. Would you like to give us an overview of how you perceive your value creation today?

7. Would you like to give us an overview of how you see your value creation in the near future? What changes and improvements have occurred?

Technology and innovation:

8. What resources do you think are most important operating in your field? (Physical, human, organisational, financial)

9. What would you say are the technologies and knowledge that fundamentally underpin your operations?

10. How were these technologies developed, did you create them yourselves, or did you acquire them?

11. Apart from Machine learning, IT and programming, in which areas do you think that Flower technologies have their biggest competences in?

Flower customers:

12. How would you describe Flower's target customer base? Who are Flower's customers?

13. Can you elaborate on the different segments of customers you serve or plan to serve?

14. What customer needs have you identified? (that you serve or plan to serve)

15. Flower is in a lot of partnerships with organizations who own solar parks, EV-chargers, and etc., and these are in turn connected to your Virtual Power Plant. How exactly are these partnerships formed? Do they pay Flower a consulting fee for letting you manage and optimize their energy usage?

Product:

16. What would you say are unique with your value proposition compared to your competitors?

17. Has Flower run into value proposition offering problems in its history? As for example shortcomings?

18. What did you do to rectify these problems? Did you develop new technologies or did you change your value proposition offerings?

19. Do you think that augmentations of your value proposition would improve it? (More features, help with installation, after sale service or such)?

20. How many improvements would you say that your value proposition are seeing right now?

21. In what ways do you think that your own developed BMS would improve your service (The BMS you are using, in what ways do you think it's currently lacking?)

22. Would you be able to provide examples of further improvements to your offering that have not yet been implemented?

Market and competitors:

23. What is your revenue model? How do you make money in the various areas you operate in?

24. Can you give an example of how you have worked on your commercialization process, from the development of new technology to commercialization?

25. Who do you believe are Flowers competitors today?

26. What would you say are your greatest threats in your ancillary services markets?

27. If another company was trying to get into your market, what do you think their biggest problems would be?

Vision and strategies (for the future):

28. What would you say is Flower's long-term vision for the future?

29. What strategies can you tell us are in place to achieve this vision?

Closing questions (When there are 5 minutes left):

30. Do you feel that there is anything else about Flower's technology strategies that we have not covered where you can provide advice or considerations?

31. Do you feel that there is anything else you would like to bring up, or do you have any questions for us?

Thank you from us!

English interview template for the second round of interviews at Flower

Info:

Who are we, and what will we do during the interview

This is the second round of interviews, here we will try to specify more of what we thought the first interviews missed or didn't elaborate on enough

The interview will be anonymous, so we won't talk about what you have said outside but rather say what the interviews have provided with information

All the questions are voluntary

The interview will probably take about 45 minutes (hard to say)

After the interview, we will create a transcription and send it to you

Introductory questions (if they're a new interviewee):

1. Would you like to briefly introduce yourself and what you currently do?

General questions about the company:

2. Can you describe your main products/services, primarily in the BESS sphere?

3. What would you describe as the company's biggest strengths currently?

Value proposition frågor

4. What would you say is unique with your value proposition compared to your competitors?

5. What would you say is the fundamental core value that your company creates today?

6. How do you realise this value? (What do you work with in order to make your value proposition true?)

7. How do you augment your product? (customer services or something else?)

8. How would you say that Flower's value proposition would change if you implemented BESS development into your company?

Resources and competencies:

9. What resources do you think that you currently possess at Flower? (As for example: Physical, Human, Organisational, Financial)

10. What types of competencies do you think are most important in operating in your field? (As for example: Threshold - that is what you need to have in order to work in your field, dynamic - what competencies are seeing regular improvements, distinctive - what are creating competitive advantages against your competitors)

11. What would you say are the technologies and knowledge that fundamentally underpin your operations?

12. From our interviews with experts, the competencies you would need are, power electronics engineers, electrochemistry engineers, electronics engineers, battery chemists, power electronic engineers, programmers that are specialised in low-level languages, measurements engineers, battery cell market experts, would you say that you have any of these competencies (resources in our model) in your company today?

13. The experts also talk about the need for manufacturers in order to build the BESS. Do you think that Flower would be able today to procure manufacturing sites as of today?

Technology acquisition:

14. How do you perceive your position with BESS technology? Are you experienced in the field, if yes, how?(På hemsidan står det t.ex. "we are also quickly becoming one of the leading grid-scale BESS developers, trusted by grid owners across Europe.", hur motiverar dem detta?)

15. How urgent would you say that the acquisition of BESS technology is for Flower?

16. How important would you say it is that the BESS is developed in-house?

17. How big changes would you say that Flower would be prepared to make to develop BESS internally?

18. Would you be prepared to co-develop BESS with other companies? Would you then prefer to do it in alliances, with suppliers or other partners?

19. What are your thoughts on the option of buying a different company and implementing their BESS technology instead of developing your own?

Finishing questions:

20. Do you have any questions for us now before we end?

Thank you for your time during the interview

Swedish interview template for the second round of interviews at Flower

Andra rundan av intervjuer:
Information:
Vilka är vi och vad kommer vi att göra under intervjun
Det här är den andra rundan av intervjuer, den här omgången är mer riktade och i dem kommer vi att försöka specificera mer av det som vi tyckte att de första intervjuerna missade eller inte utvecklade tillräckligt för att bättre kunna använda våra ramverktyg
Intervjun är uppdelad i olika delar vilka vi kommer nämna innnan vi går in på området
Intervjun kommer att vara anonym, så vi kommer inte att prata om vad du har sagt utanför, utan istället kommer vi bara nämna vad intervjuerna har gett oss för information
Alla frågor är frivilliga
Intervjun kommer förmodligen att ta ungefär 45 minuter (svårt att säga)
Efter intervjun kommer vi att skapa en transkibering och skicka den till dig

Inledande frågor (om det är en ny intervjuperson):

1. Vill du kortfattat introducera dig själv och vad du för närvarande gör?

Generella frågor om företaget (om det är en ny person):

2. Kan du beskriva era huvudsakliga produkter/tjänster?

3. Vad skulle du beskriva som företagets största styrkor?

Frågor om värdeerbjudande:

4. Vad skulle du säga är unikt med ert värdeerbjudande jämfört med era konkurrenter?

5. Vad skulle du säga är det grundläggande kärnvärdet som Flower skapar idag?

6. Hur förverkligar ni kärnvärdet? (Vad arbetar ni med för att göra ert värdeerbjudande sant?)

7. Augmenterar ni ert kärnvärde på något sätt? (kundtjänster eller något annat?)

8. Hur skulle du säga att Flowers värdeerbjudande skulle förändras om ni implementerade BESS-utveckling i ert företag?

Resurser och kompetenser:

9. Vilka resurser skulle du säga att ni för närvarande har på Flower? (Till exempel: Fysiska, Mänskliga, Organisatoriska, Ekonomiska)

10. Vilka typer av kompetenser anser du är mest viktiga för att verka inom ert område? (Till exempel: Tröskel - det som du behöver ha för att arbeta inom ditt område, dynamiska - kompetenser som leder till kontinuerlig förbättring, distinkta - kompetenser som skapar konkurrensfördelar mot era konkurrenter)

11. Vilka teknologier och kunskaper skulle du säga som grundläggande för er som företag?

12. Från våra intervjuer med experter sägs det att kompetenser ni skulle behöva för att utveckla BESS är kraft elektronikingenjörer, elektrokemi ingenjörer, elektronik ingenjörer, batterikemister, kraft elektronikingenjörer, programmerare som är specialiserade på lågnivåspråk, mätingenjörer och experter på battericellmarknaden. Skulle du säga att ni har några av dessa kompetenser (resurser i vår modell) i Flower idag?

13. Experterna pratar också om behovet av tillverkare för att bygga BESS. Tror du att Flower skulle kunna skaffa tillverkningsplatser idag?

Teknikanskaffning:

14. Hur uppfattar du er position med BESS-teknologi? Är ni erfarna inom området, om ja, hur? t.ex. på hemsidan står det t.ex. “we are also quickly becoming one of the leading grid-scale BESS developers, trusted by grid owners across Europe.”, hur motiverar dem detta?)

15. Hur brådskande skulle du säga att förvärvet av BESS-teknologi är för Flower?

16. Hur viktigt skulle du säga att det är att BESS utvecklas internt?

17. Hur stora förändringar skulle du säga att Flower skulle vara beredda att göra för att utveckla BESS internt? (Omstrukturereing? Lämna VPP marknaden?

18. Skulle ni vara beredda att samutveckla BESS med andra företag? Skulle ni då föredra att göra det i allianser, med leverantörer eller andra partners?

19. Vad är era tankar kring möjligheten att köpa ett annat företag och implementera deras BESS-teknologi istället för att utveckla er egen?

Avslutande frågor:

20. Har du några frågor till oss nu innan vi avslutar?

Tack för din tid under intervjun.

Appendix B. Case company current capabilities

Capability	V	R	I	O	Comments on placements
Ancillary system knowledge	TRUE	TRUE	FALSE	FALSE	The Ancillary system knowledge creates value for Flower as it helps them create revenue by selling ancillary systems to SVK. As the ancillary system is rather new, knowledge of how the system is perceived is rare. However, the knowledge is widely available and is thus not perceived as costly to imitate
Big engineering team	TRUE	FALSE	FALSE	FALSE	It is valuable to have an engineering team as it is fundamental to operating in a high-tech services market. However there is no shortage of engineers, thus it is not considered rare. (https://www.saco.se/studieval/yrken-a-o/civilingenjor/)
Broad knowledge from technology to project management	TRUE	FALSE	FALSE	FALSE	It is valuable to have a broad knowledge and lead projects as it's fundamental to operate in a high-tech services market. However there is no shortage of capable personnel, thus it is not considered rare.
Business network consisting of for example (SENS, Nybro Energis, Ramboll, Ellevio)	TRUE	TRUE	TRUE	FALSE	The business network that Flower has created is fundamentally valuable as it, for example, creates necessary communication channels, improves the brand and helps with knowledge gathering. It's also considered rare and costly to imitate as there are a limited number of possible partners and both time and resources are needed to keep the networks that have been created. When it comes to exploitation by the organisation, however, there is not ample enough data acquired to say that Flower is right now fully exploiting this by the organisation, therefore the O part of the VRIO is ranked as false.
CAD knowledge	TRUE	FALSE	FALSE	FALSE	Having CAD knowledge is considered valuable as it helps in planning and designing for example layouts. However, it is not considered rare or costly to imitate thus CAD knowledge is available broadly.
Communication skills	TRUE	FALSE	FALSE	FALSE	Communication skills are considered valuable as they are fundamental to operating in a market. It is also something that helps with the initiation of projects as most of the customers don't know what they want and here communication can help with streamlining the project moving forward. It's however not perceived as something rare.
Emphasis on innovation and technology	TRUE	TRUE	TRUE	TRUE	The emphasis on innovation and technology is something that every interviewee talked about. Their fail-fast, learn-fast mentality is something that Flower is using on a daily to help with their development of the industry, and it is thusly seen as clearing all criteria in the VRIO model
Energy system knowledge	TRUE	FALSE	FALSE	FALSE	Energy knowledge is essential to operate in the ancillary services market. However, it's not considered rare as there are so many people in the Swedish market with energy knowledge
Flat organisational structure	TRUE	FALSE	FALSE	FALSE	A flat organisational structure is considered valuable as it empowers the people to make their own decisions. However not rare as many companies operate in this way.
Flower hub	TRUE	TRUE	TRUE	FALSE	The Flower Hub is a new product creating value, is rare and is also costly

					to imitate for their competitors. It's however hard to say that the flower hub is currently being fully exploited by the organisation as every interviewee said that Flowers's focus is currently on the energy market, not on the residential part
Grid-scale batteries	TRUE	TRUE	TRUE	FALSE	Flower is buying and optimising batteries for trading. They are perceived as valuable as they are needed to run their power refinery. It was also said to be rare and costly to imitate in the interviews. It's however not currently the focus of the business and is therefore not considered to be fully exploited by the organisation.
Hardware integration knowledge	TRUE	FALSE	FALSE	FALSE	Hardware integration is essential for running the VPP, however not rare.
Investments from among others (41an Invest, Ellevio Energy solutions, Quik Holding AB	TRUE	FALSE	FALSE	FALSE	Investments are needed to operate the business, but it's not rare for a company to get investments and thus it's not perceived as rare
IT knowledge	TRUE	FALSE	FALSE	FALSE	IT knowledge is needed to run a VPP, not considered rare though.
ML	TRUE	TRUE	TRUE	TRUE	Machine learning is considered rare as it's fundamental for the company to run their VPP. It's also something that might not be perceived as rare on a whole, but the implementation of machine learning to help with trading on the energy market is however seen as rare as well as costly to imitate, therefore these 2 aspects are clear. It's also something that the company is fully focusing on and thus it's also being fully exploited by the organisation.
MMO	TRUE	TRUE	TRUE	TRUE	The Multi market optimisation model, coupled with the ML algorithm, is considered valuable, rare, costly to imitate and exploited by the organisation. This is motivated by the fact that the MMO is what makes Flower's VPP stand out from their competitors, giving them an advantage regarding optimising assets through several markets and making good predictions.
Multinodal optimisation	TRUE	TRUE	TRUE	TRUE	The multinodal optimisation checks all the boxes, thus it plays a big part in improving the MMO.
Negotiation skills	TRUE	FALSE	FALSE	FALSE	Negotiation skills are considered fundamental to getting contracts with investors. It's however not perceived as rare as it's widely available
Offices	TRUE	FALSE	FALSE	FALSE	Having a good office is valuable, which was corroborated by the employees. A good office is valuable in the sense that it offers a good work environment and a higher motivation for the employees to conduct good work. It's not rare, however, as offices should always fulfil the minimum requirements for a healthy work environment.
Organised chaos	FALSE	FALSE	FALSE	FALSE	The organised chaos has been valuable for the company at the start. However, as the company is currently projected to grow heavily structure is needed more and more to better streamline every process
Power refinery	TRUE	TRUE	TRUE	TRUE	The power refinery is a fundamental aspect of what creates value at Flower. Their unique implementation of it is considered rare as no other

					company is using it in this way in Sweden and the entry barriers are high thus making it costly to imitate. The organisation also revolves around the power refinery thus, it's seen as fully exploited by the organisation
Programming	TRUE	FALSE	FALSE	FALSE	Programming is considered valuable since it is what makes the company's software work properly. However, programming itself is not considered rare, or costly to imitate.
Residential batteries	TRUE	FALSE	FALSE	FALSE	Residential batteries are neededto use the flower hub but they are not seen as rare
Sites	TRUE	FALSE	FALSE	FALSE	Sites (including the things in groupings) are valuable in the sense that these things are required for operation. However not considered rare as these things are required.
Stakeholder management	TRUE	FALSE	FALSE	FALSE	The company currently needs partners which is done by stakeholder management. Thus it's considered valuable but as it's widely available it not perceived as rare
Trading	TRUE	TRUE	TRUE	TRUE	The asset-backed trading used at Flower is creating value at the company right now. The use of MMO & ML, incorporated into a VPP by their asset-backed trading algorithms and traders, is fully exploiting the opportunities to optimise trading. Thus all aspects are true.
Transparent organisation	TRUE	FALSE	FALSE	FALSE	Internally the transparency of the organisation helps with every facet of the organisation. It creates value but is not considered rare
VPP	TRUE	TRUE	TRUE	TRUE	The VPP is the fundamental product that Flower uses to create value. It's rare and costly to imitate as it uses highly developed algorithms such as ML and asset-backed trading. The usage of the MMO and ML is also unique and is what the whole company revolves around thus all aspects are true.

Appendix C. BESS information

The following chapter contains more information about what a battery energy storage system (BESS) is, what it can assist with as well as its impact on the energy industry.

To ensure Flower's ability to provide ancillary services and electricity within the power grid, the company needs an effective way to store and use energy as needed. A Battery Energy Storage System (BESS) is a versatile solution for this purpose. Essentially, a BESS stores electricity, either through special batteries or other mechanical methods, and seamlessly connects with the electrical grid to serve Flower's needs.

A BESS isn't just a typical battery; it's advanced technology with smart features. When exploring BESS options, you'll find various types tailored to specific requirements. These include lithium-ion batteries, lead-acid batteries, flow batteries, and flywheels, each with its own strengths and weaknesses related to factors like discharge time, system power, energy density, round-trip efficiency, lifespan, and cost (ADB, 2018). These technologies play a significant role in transitioning from traditional fossil fuels to cleaner, renewable energy sources, helping to bridge the gap between green energy and the growing demand for electricity.

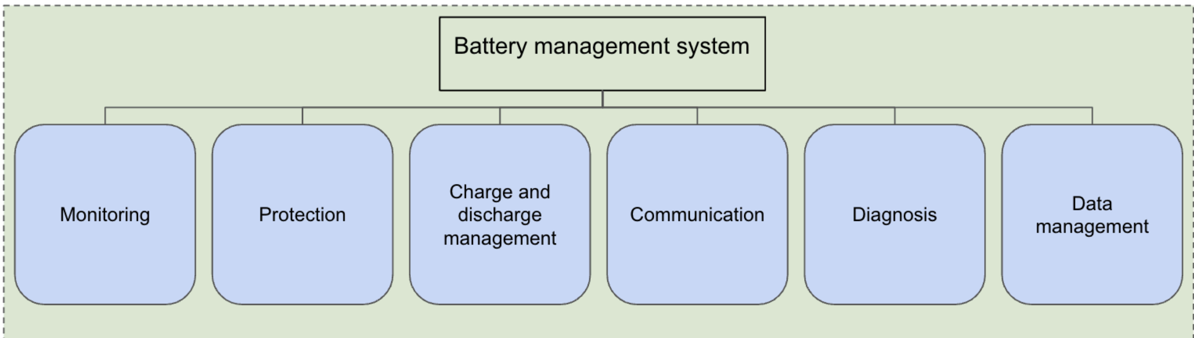

Figure A1, Topology of the BMS tasks

Unlike your everyday household batteries, a BESSs is much more advanced. It can store electricity generated from renewable sources like wind and solar power. Sophisticated software integrated into the hardware uses complex algorithms to manage energy production, and computer-controlled systems determine the best times to store and release energy into the grid. This controlled approach doesn't just help manage costs; it also ensures a steady and dependable electricity supply. (ibid.)

In the BESS, several key components work together to make the whole system function smoothly and safely. These components include the interface, Battery Management System (BMS), inverter control system, and Supervisory Control And Data Acquisition (SCADA) (ibid.). These parts ensure the BESS operates without hitches. The most important of these systems is the BMS as it handles the safety of the entire BESS.

Battery Management System

When dealing with a high voltage source there is always a risk of danger. BESS has been developed to a point where they can store so much energy, that there is always a risk of failure which might have catastrophic results (Dost & Spring, 2020; Habib et al., 2023). This might happen because of several reasons, some of them being overvoltage, thermal runaway, cathode-anode- breakdown, venting, and lithium plating (Dost & Spring, 2020; Hossam et. al., 2021). In order to combat this, a battery management system (BMS) is often used. Another problem is that overuse of a battery might lead to wear or determinants in how well a battery operates. A battery management system can therefore detect and control how the battery is operating in order to keep the battery safe and improve its longevity (Energy5 your way, 2023; Chacko, 2023; Dost & Spring, 2020; Effat, Ciucci & Wu, 2016; Habib et al., 2023). Most of the research of the BESS has been made on the Electric Vehicle (EV) market, as its compact battery cells constantly get charged and discharged. However, it is now used in every battery energy storage system where the risk of malfunction is considered high and or if the consequences of failure is deemed too risky (Lelie et al., 2018).
As earlier stated the functionality of a BMS system is primarily to make the operating of the battery safe and prolong longevity. To do this it needs to have the following functionalities (Ashwin's chronicles, 2020; Analog, n.d.; Mugo, 2023; MPowerUK, n.d.):

- Retain safety of devices and operators
  - As for example by detecting unsafe operating conditions and respond
- Protect cells of battery from damage in abuse/failure cases
- Prolong life of the battery
- Maintain the battery in a state in which it can fulfil its function design requirements
- Inform the application controller how to make the best use of the pack depending on the condition that it's in, as for example by privinding power limits, control charger etc.

A question you might ask yourself then is, do all batteries need a BMS? And the answer is no, a simple battery that does not have to compensate for smaller electronics which won't pose any threat to its user. As for example a simple AA battery might hold a lot of power but as the cells are wont allow a high amount of runaway current or any of the other, thus introducing a BMS system would only increase costs while only having a negligible effect on the users safety.

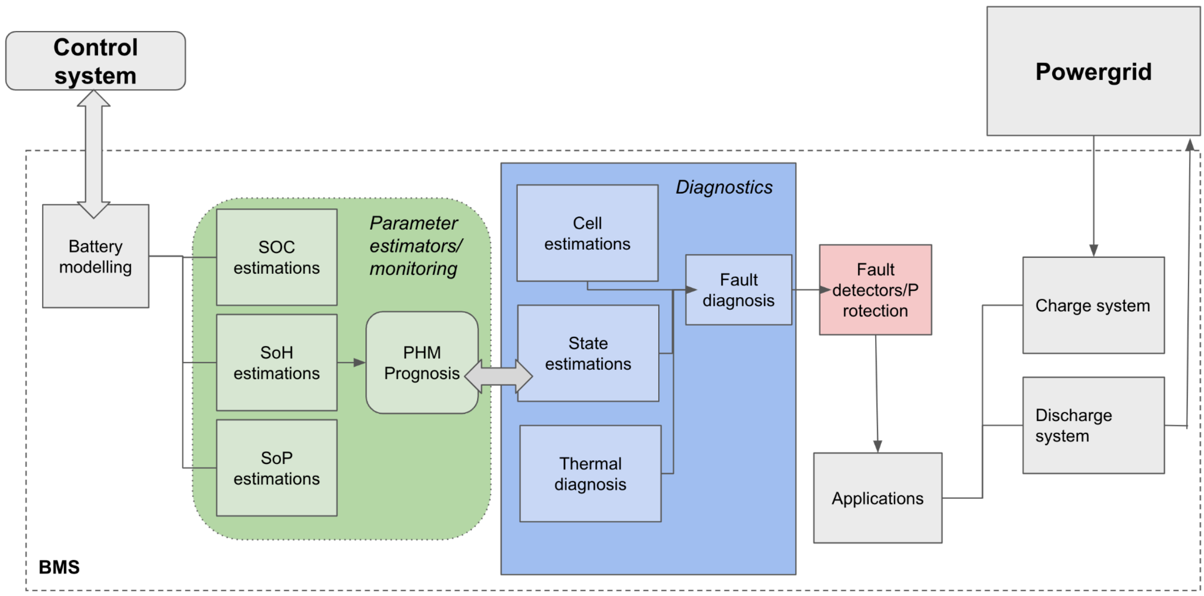

Figure A2 - Topology of the main functions inside the BMS

The general design of the BMS is thus to monitor the batteries, protect against dangerous battery behaviour, manage the charging and discharging, communicate the needed information to different systems in the design, diagnose and handle the data that is provided from the batteries as well as the external systems (Hossam et. al., 2021). In order to do this the BMS can be split up into several parts. Monitoring is the prerequisite that the BMS has to constantly perform in order to make sure that the battery is safe. Then there is protection, here a wide variety of tasks might be used as switch offs or current limiting in order to protect the batteries in case of danger. Then there's charge and discharge management that just as the protection units also controls safety but in the charge and discharging process. Diagnostics are used throughout the process with several sensors to provide accurate information in order to make prognostics of the batteries' functionality. Finally the BMS needs to communicate to its environment to provide information if the batteries are performing as the user wants it to.

BMS parameters

In order to provide all these functionalities, a black box topology can help. The designs here always extend the BMS core function of keeping the battery safe and extending its longevity. Therefore some tasks are used where some estimations of the functionality of the battery are made. Some classic examples are, state of charge (SoC), state of health (SoH), state of power (SoP) which is also sometimes called state of function (SoF)(Shen & Gao, 2019; Habib et al. 2023; González, 2021;; . From these estimators prognostics health management software is used in order to run follow up diagnostics. Sometimes more state estimations are made like state of State of energy (SoE) (Shen & Gao, 2019).

A short list of what these are and how they might affect the battery can bee seen if the table below:

- State of Charge
- State of Health
- State of Power/Function
- Prognostic health management prognosis
- State of Energy

State of charge (SoC) - Determining the state of charge of the battery is a major function of the BMS. This is due to the fact that the SoC is needed not just for providing fuel gauge indications but also because the SoC will help determine if the battery is overstressed and eventually runs the risk of breaking down. The SoC can be calculated as: $SoC = 100 * (Q_0 + Q)/Q_{Max}$, where Q_0 is the initial charge of the battery, Q is the quantity of electricity delivered by or supplied to the battery, and Q_{Max} is the maximum charge that can be stored in the battery

State of health (SoH) - The SoH of a battery describes the difference between a battery being measured and a fresh new battery. Primarily it considers cell ageing. This is of importance as an older battery risks getting wear damage which degrades the batteries and eventually makes the battery break down. SoH is defined as the ratio of the maximum battery charge to its rated capacity. SoH = $100 * Q_{Max}/C_r$, where C_r is the rated capacity.

State of Power/function (SoP/SoF) - State of power mainly consists of estimations of how resilient a battery is towards charge and discharge power according to the battery model. This considers the current, SOC and terminal voltage constraints of the battery and uses it to obtain the maximum charge and discharge power (Shen & Gao, 2019). SOF can be defined as: $SoF = \frac{P-P_d}{P_m-P_d}$, where P represents the possible power that the battery can provide, P_d stands for the power demands, P_m denotes the maximum possible supplied power of the battery (Meng, H. & Li Y-F., 2019).

Prognostic health management (PHM) prognosis - A PHM is the final part in the battery estimators. It samples the estimation functions in order to improve the availability and reliability of the batteries (ibid.). It is also used as a gateway from prognostics to diagnostics and shares its data with the different cells in order to improve the components longevity.

State of energy (SoE) - State of energy is a novel concept introduced by academia in recent years. It signifies the relationship between the remaining energy in a battery's current and its nominal total energy. These parameters directly influence the battery's lifespan, dynamic performance. Nevertheless, determining the state value isn't a direct measurement; it can only be indirectly estimated by employing the battery model, which factors in terminal voltage, current, internal resistance, and other battery characteristics (Shen & Gao, 2019). The state of energy can be calculated as $SoE = \frac{(1-\alpha) E_{nom}}{E_{nom}}$, where α is a range from 0 to 1 depending on the condition of the battery and E_{nom} is defined as the nominal energy retrieved from an initially fully charged battery in the nominal conditions(Mamadou *et al.*, 2012.

The state of these parameters depends on several parts and therefore diagnostics are used. The diagnostics consider several parts like cell estimators, state estimators and thermal diagnostics in order to sample the information and conduct fault diagnosis. In order to do this fault diagnosis programming is used which often provides extrapolations of how the battery might operate in the future by running algorithms. Some of more common ones are provided in the table below (Partovibakhsh & Liu, 2015; Sun & Chen, 2015; Wei, Huang & Kong, 2016; Bhangu, Bentley, Stone & Bingham, 2005; Qiao, Zhang & Liu, 2016; Wang, Kang, Tan & Luo, 2018; Shen, Ouyang, Lu, Li & Feng, 2018; Zhang, Xiong, He, & Shen, 2017; Bartlett, 2015; Han et Al., 2014; Li, Pan, Fan et al., 2017).

Table A1 - Table of algorithms and which state estimators they perform

Model	Estimation parameters	Algorithm
Equivalent circuit model	SoC	AEKF
	SoC	Sliding mode observer
	SoC	Particle filtering
	SoH	EKF
	SoC & SoH	Fitting on the data
	SoC & SoH	Dual Usented Kalman filter
	SoC, SoH & SoP	Least squares method
	SoC & SoE	EKF and an H infinity filter
Electrochemical model	SoC & SoH	EKF
	SoC, SoH & SoP	Electrochemical simplification algorithm
	SoE	AFEJF /Adaptive fractional order extended Kalman filter

BMS measurements

However these algorithms are highly dependent on parameter estimations which are made by measurements throughout the battery. Some of them are, current or energy usage, number of de-charges, number of deep de-charges, total and acquisition voltage, current capacity, temperature, cycle life, operating range, as well as more complex regulatory like frequency operations and robustness to electromagnetic interference (EMI) (Lelie et al., 2018; A. K. M. Ahasan Habib et al., 2023). A short explanation of these variables is provided below:

Current or energy usage (Ah, Wh) - Current measurements are used in order to monitor the battery current which is used to create the SoC algorithms (Rahimi-Eichi et al., 2013).

Charge and Discharge rate - The discharge rate will change the wear of the battery and is thus of great importance when discussing the state of health of the battery. The problem here is that in the charge and discharge cycle, lithium metal embedded in the carbon material is ionised and travels among the electrolyte, and the anode material through the porous medium to release or accept electrons. From the microscopic point of view, the main factors affecting the ageing degradation of lithium ion batteries (LIBs) are metal deposition, formation of passivation film, crack propagation, and dissolution of active material in the electrode. (Shen & Gao, 2019; Muenzel, V. et al., 2015)

Temperature - Accurately determining the operating temperature of the system poses a significant challenge for the BMS. This difficulty arises from the necessity to regulate the temperature of various battery components. If these components exceed their designated temperature range, they are susceptible to delivering inaccurate information or experiencing operational failures. (Shen & Gao, 2019; Chen et al., 2020). Sometimes even a battery thermal management system will be used just for this purpose (Madani, Swierczynski & Kær, 2017). Furthermore, the temperature of the battery cells and devices in the battery will impact its state of health (Shen & Gao, 2019).

Number of deep de-charges - The number of times that you discharge the battery also has an effect much like the charge and discharge rate (Shen & Gao, 2019; Muenzel, V. et al., 2015). When making deep-discharges this also worsens (Muenzel et al., 2015).

Current capacity - As the current capacity is of great importance when estimating the battery's maximum capacity it is often used as a variable (Kouhestani et al., 2022; Gabbar, Othman & Abdussami, 2021; Thorwaldson & Jinglöv, 2023)

Cycle life - The number of cycles under certain conditions until the battery reaches its end-of-life of typically 70-80% of the initial capacity. (Muenzel et al., 2015)

Depth of discharge - Depth of discharge is; the difference between minimum and maximum state-of-charge of a cycle.

Operating range - The BMS needs to know the range of where the battery should operate and where the battery currently is. If for example the battery is discharged to a lower level than it should be operating in, a phenomenon of plating of metallic lithium can occur on the anode during sub-freezing charging. This is permanent damage and results in not only reduced capacity but also makes cells more vulnerable to failure if subjected to vibration or other stressful conditions. There might also be problems with providing power if the battery cells have discharged too far. Overcharging might be just as dangerous as it might lead to run-away currents, fires or permanent damage to the batteries.

Frequency operations - Problems with switching might lead to EMI which in turn might disturb other areas of the operations in the BMS. Frequency response services are therefore provided through the use of in-house developed state-of-charge control algorithms. The frequency response module additionally should incorporate a P(f)/PQ mode, where P is the active power and Q is the reactive power, allowing for the adjustment of P/Q commands during P(f) to provide an offset to the droop curve. If specific marketable FCR power capacity considerations are necessary for system sizing, these might also be implemented.

BMS protection features

When diagnostics have been conducted, the battery's safe operation is assessed. If it's determined to be operating safely, the system can continue its operations, including charging or discharging the battery. However, if the BMS detects an issue during implementation, it triggers safety measures by implementing pre-installed protections. To manage these scenarios effectively, a well-structured BMS system typically incorporates a multilevel safety system employing numerous safeguards and communicating these with the BESS. These safeguards should complement each other and may take various forms, including a mix of analog and digital implementations designed to achieve the same objectives. Additional examples include but are not limited to

- ➢ Voltage fault protection
- ➢ Over-current fault protection
- ➢ Over-temperature fault protection
- ➢ Communication fault protection - Between the BMS and the surrounding system
- ➢ The oil bund provided with this transformer is an outdoor tray with an oil filter.
- ➢ Noise damping wall(s)
- ➢ Embankment(s)
- ➢ Topological/Site layout optimisation
- ➢ Fire system – An automatic fire/smoke detection system is installed and generates alarms via the SCADA system. This system automatically de-energises the total system by removing the electrical source of the energy to prevent fire.
- ➢ Emergency stop – An emergency stop will be foreseen on a strategic spot at the project site.
- ➢ Automatic text messaging service – In case of an alarm, TheBattery Connect back-office can send a text message with the alarm details to a given set of people. In case of an alarm or emergency, designated people are informed in time, in order to take appropriate actions.
- ➢ Heat Ventilation and Air Conditioning (HVAC) – The inverter contains a closed conditioning system to heat and cool the system based on both air and liquid cooling. Sufficient cooling and monitoring prevent overheating of components and also guarantees optimal performance and a longer lifetime.

- ➢ Electrical safety mechanisms – Alfen designs its systems to conform to the standards specified in paragraph 2.10 Codes and Standards.
- ➢ UL9540A conform – Cells, modules and racks of the EnerOne system have passed the test.
- ➢ Fire system – Every EnerOne outdoor rack is equipped with an aerosol fire extinguishing system, composed of a smoke detector, temperature detector and an aerosol fire extinguishing device. When both detectors are triggered, the fire extinguishing agent will be released.
- ➢ Battery Management System – The BMS monitors the batteries' relevant parameters and stops operating when it detects a first-level fire alarm. When the BMS detects a second-level fire alarm, the aerosol of the alarm cabinet is released, with all of the electrical cabinets in the system going out of operation and a signal is directly transmitted to the EMS.
- ➢ Electrical safety – The CATL EnerOne battery racks house several electrical protection components including high-voltage DC fuses, high-voltage DC switches, DC relays and manually operating low-voltage circuit breakers.
- ➢ Indicator lights – The EnerOne outdoor rack is equipped with three types of indicator lights; the red light (HV) lights on when the primary circuit is connected; the green light (LV) lights on when the secondary circuit is connected and the yellow light (warning) lights when to indicate an error.
- ➢ Cooling system – In order to keep the temperature inside the modules at the required level, integrated liquid cooling with a chiller is installed in the rack. The coolant of the liquid cooling chiller is an aqueous solution mixed with 50% ethylene glycol and 50% water. In addition, there is a R134A refrigerant in the chiller.
- ➢ IP66 level conform – In regard to the Ingress Protection Code, the EnerOne outdoor rack is tested and compliant on level IP66.

To combat this often a multi level safety design is needed. This includes several different parameter. A summation of some of these which are often used and how they are combatted are (MPowerUK, n.d.; Madani, Swierczynski & Kær, 2017; Sanino,, 2021; Chacko & Charmer, 2011)

1. Initial safety considerations
   - Cell technical design audit
2. Cell Supplier and Production Audit
   - Technical competence of staff
   - Process controls (Installed and working)
3. Cell level (internal) safety devices
   - Circuit Interrupt Device (CID) Cuts circuit if internal pressure limits exceeded
   - Shut down separator
   - Pressure vent
4. External circuit devices

- PTC resistors (Low power applications only)
- Fuses
- Cell and battery isolation. Electrical and mechanical separation (Contactors and physical separation) to prevent event propagation
- Current sensing
- Coulomb counters
- Thermistors
- Balancers
- Switches

5. Temperature regulations
   - Air cooling,
   - Phase Change Materials (PCM),
   - straight liquid cooling,
   - Ancillary liquid cooling,
   - Fin cooling
   - Tortuous liquid cooling
6. BMS Software
   - Monitoring of all key indicators coupled to control actions. (Cooling, Power disconnect, Load management)
   - Control actions or switch off in case of out of limits condition
7. BMS Hardware - Fail safe back-up
   - Hardware switch off in case of software failure. Set to slightly higher limits
   - Battery switch off in case low voltage BMS power supply fails
8. Containment / operator safety implementations
   - Robust outer container with controlled venting
   - Physical barriers between cells
   - Mandatory markings of safety on the outside of the battery packs

BMS topology

Another important aspect of BMS system is the topology used. A BMS always contains a central processing units that captures the earlier mentioned parameters in order to access how the battery is working. Then in order to better make usage of the battery it transfers electricity between the different batteries so that every battery cell is used in it's optimal base of operations. However, this has a differing amount of complexity depending on the hierarchy of the system implmeneted. A more well constructed BMS system usually contains multiple layers of hierarchy where a lower processing unit has operations of a ceratin number of battery cells. These are then hooked up to a gatewa system that contains the information from all lower processing units. This is the hooked up to a larger gateway or the central processing unit. Depending on the number of gateways used more control over each battery cell is achieved which helps in being able to get greater control of the battery cell. Thus making it better used. However, this comes at the cost of making the whole BMS more complex and also more costly.

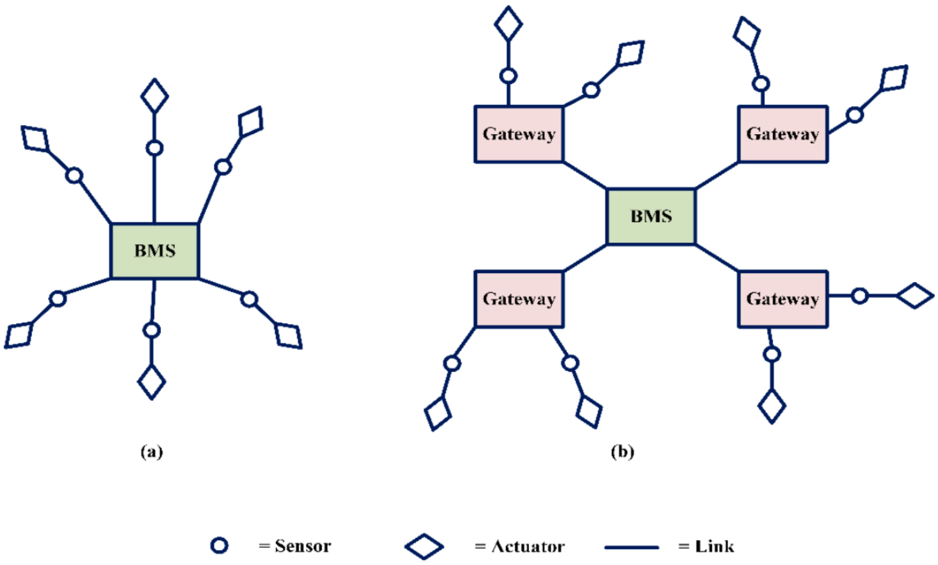

Figure A3 - Topology of a BMS (Gabbar, Othman & Abdussami, 2021)

Communication in the BMS

The BMS is only as good as the communication that is out through it. This is mainly done through communication channels through a CAN Buss that operates as the main communication channel inside the BMS. The complexity of this is outside the scope of this thesis. However, what can be said is that this channel is greatly susceptible to EMI and therefore needs thorough protections and safeguards which should be made through both protections of the channels sending and retrieving the signals, as well as, through communication channel protocols to double check that the information received was the intended.

Judicial clearings of a BMS

The BESS is something very difficult to develop and there have been many failures in the market recently as even if a product has been developed there is a low. Some problems are the large juridical aspects where a summation of some of the judicial boundary is presented below:

- ISO9001:2015 Quality management systems — Requirements
- ISO14001:2015 Environmental management systems — Requirements with guidance for use
- ISO27001:2013 Information security management
- ISO 45001:2018 Occupational health and safety management systems — Requirements with guidance for use
- EU Battery Directive

- ➢ EU RoHS Directive
- ➢ EU WEEE Directive
- ➢ IEC 61000-6-2 Immunity standard for industrial environments
- ➢ IEC 61000-6-4 Emission standard for industrial environments
- ➢ IEC 60364-1:2005 Low-voltage electrical installations - Part 1: Fundamental principles, assessment of general characteristics, definitions
- ➢ IEC 61439-2:2011 Low-voltage switchgear and control gear assemblies - Part 2: Power switchgear and control gear assemblies
- ➢ IEC 62271-200 - AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV
- ➢ IEC 60076 - Power transformers
- ➢ IEC 62619 - Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications
- ➢ UL 1973 Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications
- ➢ IEC 62477-1 - Safety requirements for power electronic converter systems and equipment
- ➢ EN 61000 6-2/6-4 Electromagnetic compatibility
- ➢ UN 38.3 UN Transportation Testing
- ➢ UL9540A Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems
- ➢ CE-certification
- ➢ IEC 61000-6-2 Immunity standard for industrial environments
- ➢ IEC 61000-6-4 Emission standard for industrial environments
- ➢ IEC 62109-1 Safety of power converters for use in photovoltaic power systems
- ➢ IEC 62109-2 Safety of power converters for use in photovoltaic power systems
- ➢ Grid connection standards of inverters in the specified country
    - ■ Finland SJV 2019
    - ■ Germany VDE AR N 4110, VDE AR N 4120
    - ■ Belgium C10/11:2019, Synergrid C10/26 homologation
    - ■ Netherlands NC RfG and Netcode elektriciteit version 1.2.1
    - ■ UK ENA EREC G99
    - ■ Ireland EirGrid Grid Code
    - ■ Spain Norma Técnica de Supervisión UE 2016/631. Revisión 1.0
    - ■ France Arrêté du 9 juin 2020
    - ■ Italy CEI 0 16: 2019 04, Allegato A.68
    - ■ Sweden EIFS 2018:2
    - ■ Austria Pending

Appendix D. Companies operating in the BESS market

Right now there are therefore multiple actors developing large battery systems with BESS implementation. Some of them are:

A123 Systems
ABB
Acobia Flux
Adara power
Aepibal
Affectus
AIT
Alfen
Alta energy
Altris
Alva technologies
Amprius
Ardeo
Askalon
Aquion Energy (ENERG2)
Battery innovation
Batteryloop technologies
Blue planet energy
Bright energy
BYD
Capture technologies
Carbon clean
CATL (Contemporary Amperex Technology Co. Limited)
CE
CellCube
Cener
Circe
Cobra
Commeo
Corre energy
Corvus energy
CTEK
Digital route
Dlabaratory Sweden
DNV
Doosan grid tech
E.On energy solutions
E2S Power
Ecobarage Sweden
Ecoult
EDF
EDP renewables
Egen E1
Electroflett
Electrovaya
Eldpedison
Elia
Enel
Enel x
Energia salv
Energy storage nl
Energy vault
Enequi
Eneryield
Engie
Enphase Energy
Enspired
Epishine
Ericsson
Ess inc.
Eunice energy group
Evapco for life
Exert
Fluence
Fluistcom
Form energy
Frey clean battery solutions
General Electric (GE)
Geyser batteries
Giga storage
Granito electro
Gravitricity
Green charge networks
Hek EAD
Higview power
Hitachi
HTHium
Huawei
Hungarian battery association
Iberdrola
Imergy power systems
Ingrid Capacity
Innolith freedom
Intab
interface-Teknik
Invinity energy systems (Formerly redflow)
Komag
Leclanche
Liquid ind
LG Chem

LG energy
solutions
Lumenion
Moixa
Mitsubishi power
Naturgy
NEC Corporation
NEC Energy
solutions
NGK
Nidec
Norgald
Northvolt
Panasonic
Pika Energy
Pirtium
PowerCellsweden
Powervault
Powin energy
Primus power
Public power
corporation

Qinous
redT Energy
Regin
Romero group
S&C Electric
company
Saft (subsidiary of
Total Energies)
Samsung SDI
Sharp
Siemens / Siemens
energy
Solar Jinks
Sonnen
Soomec innovative
power solutions
Spare technology
Spp development
SQM
Stem, Inc.
Sub
Sumitomo

Sungrows
Sunrun
Sunverge
Tesla
Texel energy
storage
TNO Innovation
for life
Total energies
Tvinn
UNDA
Uniper
UTB
Utilifeed
Varta storage
Vionx Energy
Voith
Wärtsilä
Xtralis
Younicos
(Subsidiary of
Aggreko)