Improving the coordination of the Supply Chain
- A case study of the battery charger manufacturer Micropower and its subsidiary Ecotec

Master Thesis

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During the last 10 weeks, we have had the privilege to fulfil a challenging and stimulating project for the company Micropower. A special thank you is first addressed to our contact at the company, Torbjörn Gustafsson, who gave us the responsibility and the opportunity to lead such study. We also want to thank the managers at Micropower involved in the project, especially Andreas Mattisson and Annika Magnusson who took time for interviews and showed us the production site. Thank you to our contact at Ecotec, Jim Keyser, who has been available for Skype interviews even though he is working at thousand kilometres away from Sweden.

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Växjö, 27th May 2016

Camille Gay

Erik Norrman
Abstract

Title: Improving the coordination of the Supply Chain – A case study of the battery manufacturer Micropower and its subsidiary Ecotec

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Tutor: Petra Andersson

Examiner: Dr. Lars-Olof Rask

Course: 4FE14E – Master thesis

Research questions: How should the supply chain within Micropower and Ecotec be coordinated in order to minimize the costs and keep a high customer service level?

1. What kinds of activities take place within the supply chain of Micropower and Ecotec and how are they coordinated?
2. What kinds of wastes can be identified and why do they occur?
3. What should be done in order to minimize these wastes?

Purpose: The overall purpose is to improve the coordination of the supply chain between the two facilities to minimize the airfreight without affecting the customer service level. The first objective is to define what kinds of activities take place within the supply chain and how they are coordinated with each other to identify the wastes. It will then be investigated why they occur. Finally, suggestions and solutions will be formulated to eliminate these wastes. Considering the expansion phase of the case company, the purpose of this thesis also covers general learnings for future supply chain setups with offshore subsidiaries.

Methodology: This case study was conducted with both deductive and inductive approach. The data were gathered through semi-structured as well as unstructured interviews and own observations. The scientific credibility was ensured by avoiding assumptions, setting feedback sessions with the managers, following steps of the VSM and the usage of multiple sources.

Conclusion: The inter-functional coordination within Micropower should be improved by better matching the upstream activities with the downstream. This can be done by better sharing the information and supporting the assembly activities with an increased stock level of components. Regarding the inter-organizational coordination, the information sharing should be bilateral rather than currently unilateral between Micropower and Ecotec. An open coordination document should be setup and include more supply-related information to enable more visibility and therefore better organizing the production planning at Micropower. At Ecotec side, the inventory management should be more effective by keeping only the most popular variances in stock and the information should be shared by its main customers regarding the forecasting. For future offshore subsidiaries, the coordination mechanisms should be applied already at the beginning of the set-up. The areas of responsibility shall be declared between the companies in order to achieve an effective coordination of the supply chain.

Keywords: Supply Chain Coordination, Lean Supply Chain Management, Total Logistics Cost, Value Stream Mapping
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List of abbreviations

3PL Third party logistics
AGV Automated Guided Vehicle
CT Cycle time
DP Double pack charger
EDI Electronic data interchange
ERP Enterprise Resource Planning
FIFO First In First Out
HF Charger High frequency charger
LSCM Lean Supply Chain Management
MRP Material requirements planning
R&D Research and development
SCM Supply Chain Management
SP charger Single pack charger
TT Takt Time
TPS Toyota production system
VAT Value added time
VSM Value stream mapping
WIP Work in progress
1 Introduction

The introduction chapter will present the area of study that has been determined together with the case company Micropower. The problem discussion will emphasize the different issues the company is facing which will be the foundation of this thesis. This will lead to the research question as well as the purpose. The facility in Växjö will be referred to as Micropower only, whereas the corporate group will be distinguished by naming it Micropower Invest.

1.1 Background

The globalization has changed the business environment the last decades. Two of the main drivers have been the technology developments and an expanding global market (Verweire & Berghe, 2004). Challenges, such as shorter product-life cycles and a need of distinguishing from competitors, have incurred from these drivers (Li, et al., 2014). In response, companies have changed their organizations towards focusing on their core business and outsourcing the unnecessary activities. This has led to more actors involved in the product’s value adding journey towards the customer. It has also led to an increasingly competition between supply chains rather than a competition between individual companies (Dwivedi & Butcher, 2009). Time has therefore grown in importance the last decade as a way to be distinguished from competitors. Reaching customers as quickly as possible has become an essential and valuable strategy for companies to achieve (Demeter, 2013).

The battery charger manufacturer Micropower is a company where short time to market is an important part of their business strategy. For the subsidiary Ecotec, located in Ohio, USA, is this an essential part of the business strategy in order to cope with the highly competitive North-American market. The company has built its businesses on fast deliveries and would quickly loose market shares if they would fail to do it. The chargers are supplied by the mother company Micropower, located in Växjö (Sweden). The supply chain between the two facilities mainly consists of two types of chargers, divided into 26 different variances, which are manufactured at Micropower. The final customization regarding types of cables, software configurations and outer protection on the chargers takes place at Ecotec (Gustafsson, 2016). The shipments are carried out through third party logistics (3PL) actors either by airfreight or ocean freight depending on urgency (Gustafsson, 2016).
The challenging competition between supply chains the last decade has increased the importance of Supply Chain Management (SCM) which involves the planning and management of the movement of goods including sourcing, procurement, value adding and delivery to the customer. Most importantly it also includes the coordination of the supply chain and the collaboration with channel partners (Jonsson, 2008). Coordination is defined as “…managing dependencies between activities” (Malone & Crowston, 1994, p. 91). From a supply chain perspective, this would then emphasize actors with conflicting interests performing interdependence activities to achieve the overall system’s objective. From a Micropower-Ecotec perspective, the overall system’s objective is to achieve a coordination that is cost efficient without interfering with the lead-time to the end-customer (Gustafsson, 2016).

1.2 Problem discussion

Fast deliveries and customization are two counterproductive objectives, which complicate the coordination of the supply chain (Li, et al., 2014). In order to cope with this challenging condition Micropower and Ecotec has developed a mix of make-to-forecast and assembly-to-order strategy. Firstly Ecotec places an order to Micropower, which they expect to be delivered with ocean freight. Thereafter the final customization of the chargers takes place when the order from the customer has arrived to the company, and the delivery takes place within a week to the customer (Mattisson, 2016).

Figure 1. Critical areas in the supply chain (own figure)
However, when studying the shipments costs between the two facilities it becomes obvious that there is a lack of coordination in the supply chain. Instead of shipping all the chargers through the cost efficient alternative ocean freight, a considerable number of chargers are sent with the much more expensive alternative airfreight. This negatively affects the companies’ profit margin. Obviously, the objective between the companies is to send the chargers through ocean freight to be cost efficient, even so it takes an appreciable difference in time between the two options (Gustafsson, 2016).

There is a clear sign that the coordination of the supply chain is lacking when the objective of the shipping arrangement is not achieved. Most probably, the lack of coordination is not only isolated to culminate in increased airfreight shipments. Other types of un-displayed wastes certainly occur along the supply chain which may affect the costs and the lead-time to Ecotec’s customers. There is therefore a need to investigate how the decision-making is carried out between the interdependent functions in order to identify an effective supply chain coordination between Micropower and Ecotec (Gustafsson, 2016). An effective supply chain coordination arises advantages such as decreased lead times, elimination of excess inventory, increased customer satisfaction, improved service level, decreased manufacturing costs and increased flexibility coping with fluctuations in demand (Arshinder, et al., 2008).

From a lean focused perspective, these advantages would be referred to as a waste-free supply chain. Waste is important to eliminate since it uses resources but does not add any value to the product (Pavnaskar, et al., 2003). Lean Supply Chain Management (LSCM), the integrated concept of lean and SCM, has the same aspiration as supply chain coordination – to minimize wastes and costs along the supply chain (Bruce, et al., 2004) and can therefore be used as an approach to improve the supply chain coordination. Value Steam Mapping (VSM), a tool within LSCM helps to visualize the activities and the information flow that takes place within the supply chain. This provides the users with a clear overview of the supply chain and enables identification of different kinds of wastes in the material flow (Bertolini, et al., 2013). Further on, LCSM also provides a tool to eliminate and minimize the displayed wastes called the Knowledge Management Framework, which refers to the knowledge and decision making (Liu, et al., 2013). Nevertheless, when analyzing and evaluating the types of wastes along the supply chain, the total cost concept becomes relevant in this context as.
wastes are creating costs for companies. Thus, the total logistics cost concept enables translating the types of wastes into costs instead (Arnold, et al., 2008).

A LSCM approach integrated with the total logistics cost concept may therefore, applied to this context, facilitate the improvement of coordinating the supply chain between Micropower and its subsidiary Ecotec.

1.3 Research Questions

As a result of the problem discussion in the previous chapter regarding the current supply chain setup between Micropower and Ecotec the research questions have been structured as followed:

- How should the supply chain within Micropower and Ecotec be coordinated in order to minimize the costs and keep a high customer service level?
  1. What kinds of activities take place within the supply chain of Micropower and Ecotec and how are they coordinated?
  2. What kinds of wastes can be identified and why do they occur?
  3. What should be done in order to minimize these wastes?

1.4 Purpose

The purpose is to improve the coordination of the supply chain between Micropower and Ecotec in order to minimize the costs and keep a high customer service level. Firstly, the activities within the supply chain of the two facilities will be illustrated to then identify the potential wastes that impact the costs as well as the customer service level. Finally, different solutions regarding these wastes will be formulated.

Further on, considering the expansion context of Micropower, the purpose of this thesis is also to provide the company with general learnings of how they effectively may coordinate their supply chains with future offshore subsidiaries.

1.5 Limitations

This study carries out a qualitative and quantitative research for the case company Micropower based in Sweden and its subsidiary Ecotec based in Ohio, USA. The thesis is limited to concepts mentioned in the problem discussion. Further on, limitation has
been made to not focus on the reverse logistics that is taking place between the two facilities. The field of study is the supply chain management as the thesis deals with the supply chain coordination and lean supply chain management. Furthermore, the study focuses only on the operational and tactical dimensions regarding the coordination and does not cover a strategical perspective.

Since Micropower manufactures a high amount of components included in the battery chargers, the scope of this study has been limited to cover the assembly line of the chargers at Micropower to the point where the final order for Ecotec’s customers is shipped.

Figure 2. The limitation of this thesis (own figure)
1.6 Disposition of the thesis

The master thesis started with the first chapter which introduced the context and the problem discussion leading to one main research question divided into three sub-questions. The purpose is thus presented as well as the limitations to show the scope of the study. The thesis will continue with six chapters as shown in the model below (Figure 3).
2 Case company introduction

As the case company Micropower is a part of the Micropower group, this chapter will firstly introduce this latter to provide an overview of the corporate structure. Furthermore, this chapter will display the structure and relevant information related to how the case company is operating. As the focus of this thesis also includes the US-based subsidiary, Ecotec, this will be presented to give a complete picture of the connection between the two companies.

2.1 Micropower Invest

Micropower is an international group operating within the battery charger industry. The company was founded in 1984 in Växjö (Sweden) where the core manufacturing and research and development (R&D) take place. The group employs a total of 158 people over the world (Micropower, 2013). Micropower has grown over the years through different acquisitions of smaller companies. The current corporate group includes nine different companies that are located in Sweden, Finland, China as well as USA (Figure 4). Therefore, by being located in different countries the group is now a true global supplier and is able to export and supply to a growing number of countries. As a result, more than 400 000 battery chargers and power supply units are sold every year (Micropower, 2013).

Figure 4. Micropower Invest over the world (Micropower Group, 2014)
The Micropower group includes two R&D centers that are currently located in Växjö, Sweden and Salo, Finland. In these centers, the chargers and charging specifications are developed and tested by engineers (Micropower, 2013).

The production operations are divided in a way that the high frequency chargers are developed and manufactured in Salo while low frequency chargers are developed and manufactured in Växjö (Micropower, 2013). This latter is the head office and the center for development, marketing and sales of traction battery chargers. It supports the group’s companies and representatives by supplying products. The sales operations are nevertheless done globally (Micropower, 2013).

At the end of 2014, Micropower Invest had an annual turnover of 292 million SEK with a profit of 30 million SEK. Despite the last years’ expansion, which has implied big investments and decreased profits, Micropower Invest has a stable financial situation with a total equity ratio of 59 % and a cash liquidity of 186 % (Annual report, 2014).

2.2 Micropower

The company Micropower based in Växjö (Sweden) is today the market leader of the chargers for forklifts applications in Northern Europe. At the facility, most of the manufacturing operations are carried out. The company’s range of products is divided into 4 subcategories, which include HF chargers, service chargers, conventional chargers and thyristor or transistor-regulated chargers. The choice of charger depends on the type of battery, area of use and charging time (Micropower, 2013). Moreover, the company also provides accessories and components that are assembled to the products according to customers’ orders.

The firm is manufacturing to order as the manufacturing process starts as soon as the customers’ order is received. There is a safety stock to cover the needs of the different subsidiaries nevertheless this represents a few amount of products as the variances differ among the customers’ orders. Simple software configurations are made within the facility but the customization takes place directly at the subsidiaries. At this step, different models of the products can be created by assembling different components (e.g. different length of cables and different sockets) (Gustafsson, 2016).

The main customers of Micropower are truck manufacturers based in Scandinavia as well as manufacturers of Automated Guided Vehicle (AGV) systems in Europe and
USA, and battery manufacturers and distributors in Europe. The principal customer of Micropower is the forklift manufacturer Toyota located in Mjölby, Sweden (Gustafsson, 2016).

Micropower supports other companies of the group, especially Ecotec based in USA. One of the two production lines is dedicated to the two types of charger modules that are delivered to Ecotec (Figure 5). These two types of charger modules differ through having single or double motors, which impacts the charging time. Further on, the two types of modules are divided in 26 different variances depending on different characteristics (components and voltages). However, the appearance of the different variances remains the same (Mattisson, 2016).

![Figure 5. Two types of chargers sold by Micropower to Ecotec (Micropower Group, 2014)](image)

### 2.3 Ecotec

Micropower has expanded his network with the acquisition of Ecotec Ltd in 2012. The company is located in Troy, Ohio. The core business of Ecotec is the marketing and simple customization of chargers in order to supply the North American market under their own label (Micropower, 2013). The products from Micropower are delivered to the facility by ocean freight or airfreight as semi-finished products (Mattisson, 2016). The reason behind this is that the customers require different kinds of customization. This results in a high amount of variations that Micropower would not be able to handle itself. Micropower therefore delivers the chargers 98% finished for Ecotec. Besides these operations, warehousing, packaging and labeling operations also take place at Ecotec (Gustafsson, 2016). Ecotec’s customers are divided into three different types.
First, the company’s biggest customer in terms of turnover is the battery manufacturer. The two other customers are the forklifts manufacturers as well as the dealers that are selling the products to service companies (Gustafsson, 2016).
3 Methodology

The following chapter will explain how the research study was conducted. This will outline the motives of the study and how the research is structured as well as how relevant data are collected and put in relation with theories. It is done by defining the scientific perspective and approach, the research method, the techniques of data collection, the analysis method and the scientific credibility. The importance of considering ethical perspectives while conducting our research activities will conclude this chapter.

3.1 Scientific perspective

The scientific perspective considers how researchers build the theory as well as the way social reality should be studied (Bryman & Bell, 2015). There exist two opposing approaches. While positivism focuses on observable phenomena in order to generate reliable data, the hermeneutics perspective aims to understand the human behavior (Remenyi, 1998). In this research, the positivistic approach has been followed as the existing theories and observations form the basis for the study rather than interpretations and own hypotheses. The data based on a literature frame have then been analyzed to support the research development. As Bryman and Bell (2015) outline, the collection of data should be done without any influence of existing theories. Therefore, the objectivity of the data was taken into consideration in this research as the theories have been used for empirical data interpretation (Saunders, et al., 2009).

3.2 Scientific approach

According to Saunders et al. (2009), the relation between research and theory is the main consideration of the scientific approach as the theory can be made in an implicit or explicit manner in the design of the research. There are two main types of scientific approaches: deductive and inductive. As the case company’s problem covers a wide subject area, it has been necessary to first understand the research context in order to determine on which theories the researchers should focus. Using the inductive approach leads to collect relevant data for then define the theory frameworks (Saunders et al., 2009). Thus, the research started by establishing a Value Stream Mapping that helped to illustrate the material and information flow between Micropower and Ecotec. As a result, the researchers had a better understanding of which are the critical issues and this clarified which specific theories were relevant to study. A deductive approach was thereafter used, as these theories constituted the basis for the research.
3.3 Research approach

Bryman and Bell (2015) distinguish two approaches while conducting a research study, which are the quantitative and qualitative researches. Generally, these are used to understand what are the essential points that have to be considered to analyze the data in a meaningful way (Saunders, et al., 2009). In this research, the quantitative data, represented in terms of absolute figures (Saunders et al., 2009), have been gathered through obtaining operational data from the case company. These are mainly related to lead-time, frequency of deliveries as well as capital tied-up, and facilitate the comprehension of the processes within the supply chain of Micropower and Ecotec. In order to have a complete overview of the process, a qualitative approach has been used as well. The qualitative research method considers only “non-numerical” data (Saunders et al., 2009). These have been collected through observations as well as interviews of key persons within Micropower and Ecotec. This enabled the researchers to have a better understanding about the material and information flows as well as the structure of the supply chain of the two facilities.

3.4 Research design

The research design of this thesis followed a case study design through studying and analyzing the case company Micropower and its subsidiary Ecotec. The case study approach is relevant when the researcher studies a contemporary phenomenon and addresses a descriptive question or an explanatory question (Yin, 2014). The main question of this thesis intends to show ‘how’ the supply chain of the two facilities should be coordinated; hence it followed a descriptive case study approach. The following sub-questions targeted ‘what’ kind of activities take place and ‘what’ kinds of wastes can be identified as well as and ‘how’ to minimize these. An exploratory case study approach was therefore applied in order to answer these questions (Yin, 2014).

One main advantage while conducting a case study is that an entire organization can be investigated in detailed. The highly focused attention enables the researcher to study the order of events as they occur or instead focus on the relationship between functions, entities or individuals (Zikmund, et al., 2010). A Value Stream Mapping approach was used within this study to enable a visualization of the supply chain and identification of critical areas within it.
The successfulness of the case study highly depends on the collaboration between the organization that is studied and the researcher (Zikmund, et al., 2010). To ensure the successfulness of this study, a frequent dialogue between Micropower and the researchers were established whereas ongoing progress and implications were discussed.

The data collection process is critical to accurately answer an explanatory research question. Both quantitative and qualitative data are important to collect in order to gather a multiple perspective of the studied object (Green, 2011; Blumberg, et al., 2011). The data collection of this study includes interviews with key persons in the supply chain as well different kind of quantitative data.

3.5 Data collection

Since a case study includes a variety of different data collection methods (Green, 2011), this case study has been limited to only apply a few of them:

- Interviews
- Observations
- Management documents
- Financial documents
- Operational documents

3.5.1 Primary data collection

Primary data are sought for the proximity to the truth (Blumberg, et al., 2011) and involves direct contact with respondents or other direct data collection methods performed by the researcher. Primary data are considered having a high credibility and validity (Given, 2008).

Interviews

In this study, the primary data collection involved semi-structured as well as unstructured interviews with people working directly or indirectly within the supply chain of Micropower and Ecotec. Semi-structured interviews have been divided into different themes, which have been addressed during the interview. This construction gives the respondent freedom to answer while the moderator can ask following-up questions (Bryman & Bell, 2013). The main advantages with this kind of interview are
that it provides an ability to address more specific issues (Zikmund, et al., 2010) and a broader data collection than structured interviews (Bryman & Bell, 2015). To interview persons located at Ecotec in USA, the researchers used the online communication tool Skype. This method has the flexibility of a telephone interview but is still similar to an in-person interview (Bryman & Bell, 2015).

To facilitate the analyzing and ensure that no information has been accidently excluded, the researchers recorded the interviews. This method also implies a fully focus on the interview and to ask following-up questions instead of being occupied at taking notes (Bryman & Bell, 2015). Due to the high degree of time consumption and the confidentially of certain data, the interviews were not transcribed. Nevertheless, notes have been taken while interviewing the participants.

Interview guides, which can be seen in the appendices, were conducted to enhance the quality of the interviews. The interview questions origin from the pre-conducted theoretical framework. Ongoing emails have been sent to the managers in order to complete some information from previous interviews as the researchers may have missed some relevant data and thought about those later while sorting the questions’ answers. This allowed having all the important information to lead the study.

The respondents were contacted in advance by receiving a Project description at the beginning of the project so they could be aware of the nature of the project and could be well prepared for the interviews. The document includes a brief description and objectives of the project as well as the approach and the time frame.
To increase the researchers’ knowledge of the supply chain between Micropower and Ecotec and the products and activities it includes, primary data have also been gathered through structured observations at the production site in Växjö. A structured observation involves inspecting or observing physical facilities with a pre-determined study objective (Green, 2011). The observations aimed to collect knowledge regarding different procedures, lead times and set-up times and were therefore of a more quantitative nature. Those enabled the researchers to take notes, clock the activities and gather knowledge regarding how the employees on the shop floor are performing their

### Table 1. Data collection through different methods

<table>
<thead>
<tr>
<th>Methods</th>
<th>Date</th>
<th>Respondents</th>
<th>Position</th>
<th>Type of interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviews</td>
<td>14/03/16</td>
<td>Torbjörn Gustafsson</td>
<td>Vice President of Micropower</td>
<td>Semi structured face to face interview</td>
</tr>
<tr>
<td></td>
<td>13/04/16</td>
<td>Andreas Mattisson</td>
<td>Production Manager of Micropower</td>
<td>Semi structured face to face interview</td>
</tr>
<tr>
<td></td>
<td>19/04/16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16/05/16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>13/04/16</td>
<td>Annika Magnusson</td>
<td>Order Manager of Micropower</td>
<td>Semi structured face to face interview</td>
</tr>
<tr>
<td></td>
<td>19/04/16</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>16/05/16</td>
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</tr>
<tr>
<td></td>
<td>26/04/16</td>
<td>Jim Keyser</td>
<td>General Manager of Ecotec</td>
<td>Semi structured Skype interview</td>
</tr>
<tr>
<td></td>
<td>19/04/16</td>
<td>Operatives</td>
<td>Shop floor - Different areas (Production/Packaging/Storing)</td>
<td>Unstructured face to face interview</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Observations</th>
<th>Date</th>
<th>Department/areas visited</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>13/04/16</td>
<td>Manufacturing lines</td>
</tr>
<tr>
<td></td>
<td>19/04/16</td>
<td>Assembly lines</td>
</tr>
<tr>
<td></td>
<td>19/04/16</td>
<td>Packaging area</td>
</tr>
<tr>
<td></td>
<td>19/04/16</td>
<td>Storing area</td>
</tr>
</tbody>
</table>
work and how the procedures take place. In order to show the objectives and outcomes of such method, a checklist of the observations is presented in the table below.

<table>
<thead>
<tr>
<th>Date</th>
<th>Area visited</th>
<th>Objectives</th>
<th>Operations</th>
</tr>
</thead>
</table>
| 19/04/16 | Manufacturing Assembly | • Understand the manufacturing process of the components and where these are stored and how these are classified etc.  
• Understand the assembly process and what kinds of operations are done at each station  
• Understand the information flow through the stations  
• Defining the time of the assembly process  
• Defining the time to move the chargers from the assembly area to the packaging area | • Clocking of the processes’ time  
• Checking of the orders  
• Checking of the quality document  
• Clocking of the chargers’ internal transportation |
| 19/04/16 | Packaging | • Understand the packaging process  
• Defining the time required for this operation  
• Defining the time required to move the chargers from the packaging area to the storing area | • Clocking of the process  
• Clocking of the chargers’ internal transportation |
| 19/04/16 | Storing | • Understand the storing process  
• Understand how the storage is organized | • Counting the number of chargers/rack |

Table 2. Observations checklist

3.5.2 Secondary data collection
Secondary data include information and observations, which are already gathered and recorded by someone else than the researcher (Zikmund, et al., 2010). Secondary data include among others, newspaper articles, sales analysis summaries and annual reports (Blumberg, et al., 2011). Secondary empirical data collection within this study includes data already gathered and compiled by Micropower and Ecotec. This considers for instance operational data, shipment document, and production planning document.
Especially the shipment document, also referred to as Open order document, has been used as secondary data.

The secondary data also involve a theoretical literature gathering in order to follow the deductive approach this study has. The literature gathered firstly formed the basis of the interview guide and secondly formed the theoretical framework to enable the analysis of the collected empirical data. The literature consists of Supply Chain Coordination, Total Cost Concept and Lean Supply Chain Management and have been gathered through peer reviewed articles and books to ensure the credibility.

Confidentiality

Since this thesis handles important internal information regarding Micropower and Ecotec’s operational business, such as costs, profit margins and lead times, confidentiality has to be respected. To ensure the confidentiality the quantitative data presented in the final version have been modified. Moreover, to ensure the confidentiality of the qualitative data, the researchers had an ongoing dialogue with the company about what data is considered to be critical to publish.

3.6 Analysis method

A data analysis is the procedure to make the gathered data understandable and involves determining consistent patterns as well as summarizing the relevant details revealed in the study (Zikmund, et al., 2010).

This thesis used the pattern matching technique to analyze the case study data. Pattern matching compares gathered empirical findings with predicted findings (Yin, 2014). Since this study followed an inductive to deductive approach the predicted findings consist of a pre-conducted literature framework that are compared with the empirical findings. The pattern matching analyze method is applicable on both explanatory and descriptive case study approaches which are the approaches used within this study (Yin, 2014).

To handle the gathered data in practice, the researchers have used different tools. In order to facilitate the analysis of the qualitative data gathered from interviews, the researchers used coding and labeling which enable identification of important and frequent topics (Bryman & Bell, 2015). Furthermore, the documents that provided
quantitative data have been analyzed by comparing the data with the one gathered in the interviews. The practical handling of the quantitative data was facilitated through displaying the data in tables and figures (Bryman & Bell, 2015).

3.7 Scientific credibility

Four different quality criteria have been applied in this study to ensure the overall quality and credibility. Construct validity, which reflects the identification of correct measures for the concept being studied (Yin, 2014), was firstly applied in this study. To increase the constructed validity, the researchers used multiple sources of evidence but also had an ongoing reviewing process performed by stakeholders. Next criterion applied is the Internal validity, which is an important quality measure to ensure the quality of an explanatory case study (Yin, 2014). Internal validity refers to if there is a good match between the researcher’s observations and the theoretical ideas this latter develops (Bryman & Bell, 2015). In this study the internal validity was ensured through pattern matching analysis, which connects the theory with the collected empirical data. While performing the research activities, there was a high emphasis on constructing the validity particularly as feedback sessions were set up weekly with the managers involved in the project. During these sessions, they have checked for instance the process flow and the empirical findings that the researchers have developed and collected. By confirming the exactitude of all the data and information that are disclosed, this has helped to increase the validity of the project. As some data were missing because of lack of time or difficulty to clock the processes at the US facility, the researchers have made estimations. However shop-floor workers and the management reviewed those in order to ensure the validity.

The third criterion, External validity, rather refers to in which extent the findings can be generalized across social settings (Bryman & Bell, 2015). This was ensured through creating a ‘future value stream map’. The generalizability of this map is not only applicable to Micropower but also to similar business in order to facilitate the supply chain coordination between the parent company and its subsidiaries. The last criterion followed in this study is Reliability, which reflects how replicable the study is (Zikmund, et al., 2010). In order to improve the reliability the researchers intended to do the study as transparent as possible for the reader.
3.8 Ethical considerations

According to Brinkmann and Kvale (2005), qualitative research leads to an interaction between the researchers and the participants of the study. Blumberg et al. (2011) outline the importance of ethics as it aims to guarantee that there will be no negative consequences from this interaction (e.g. putting the participants under pressure, not respecting participants’ confidentiality and rights, misrepresenting their answers). The authors state three guidelines to apply ethics while conducting research activities.

Firstly, the researchers must clarify the outcomes expected from the interviews to make the participants aware about how they can help. Another important point is to disclose their rights to ensure they will be protected. Then, the researchers should be certain about the participants’ consent in the research activities in order to guarantee their confidentiality.

As the research activities should be done in a responsible way (Blumberg, et al., 2011), the ethical considerations have been taken into account while conducting the interviews for this thesis. This was the case since the characteristics and the goals of our research
as well as the rights of the respondents were explicitly displayed before the interviews. The respondents had access to the questions in advance in order to make them comfortable and aware about the potential outcomes of such interview. The confidential data are protected, as there exist a written agreement with Micropower that states the company can check the thesis before any publication. Bryman and Bell (2015) outline that it is usually easier to change the data from quantitative research in order to ensure the confidentiality. Thereby, the confidentiality of the sensitive data from the quantitative research were guaranteed by changing the figures.

3.9 Summary of the methodology

To summarize the combination of different approaches used in the research study, a figure was developed for the reader. This illustrates and provides a better overview of the constructed methodology used for this thesis and can be seen below.

![Methodology model](image_url)

Figure 7. Summary of the conducted methodology (own figure)
4 Theoretical framework

The theoretical framework firstly provides the reader with an exhaustive description of supply chain coordination. This topic is relevant in order to further analyze the current coordination of the supply chain between Micropower and Ecotec. Moreover, the theoretical framework covers Lean Supply Chain Management and the Total Logistics Cost, which are two important concepts in order to analyze the current performance of the supply chain between the two facilities.

4.1 Supply Chain Coordination

4.1.1 General definition

In the last decades, the Supply Chain Management (SCM) has evolved and goes beyond the individual firm’s perspective towards a more holistic view of the product’s journey from raw material to delivered finished product to the customer (Jönsson, 2008). The competition is no longer between individual companies but rather between supply chains (Dwivedi & Butcher, 2009). With a competition between supply chains, involving multiple actors, there is a clear need of an effective coordination of the supply chain in order to provide short and reliable lead times (Mello, et al., 2015). The coordination is defined by Malone and Crowston (1994, p. 91): “Coordination is managing dependencies between activities”. This definition emphasizes actors
performing interdependent activities, which individually may have conflicting interests. The concept is therefore also relevant from a decision-making process that maintains the order and stability of a system (Malone & Crowston, 1994). The term supply chain coordination therefore implies managing the different actors and activities within a supply chain in order to achieve a global system objective (Arshinder, et al., 2008).

The supply chain is usually composed by various activities that require interaction between the different supply chain members while sharing information and resources. These activities are organized into different functions such as logistics, inventory, purchasing and procurement, production planning, intra- and inter-organizational relationships and performance measurements (Arshinder et al., 2008). Ballou et al. (2000) states that the coordination of these different functions is a key aspect to enhance supply chain management’s performance. The functions represent different interdependencies in the value chain towards the customer. The functional interface between different business units challenges the coordination (Mello, et al., 2015).

By redesigning the way decisions are made, the workflow’s organization and the resources handling between the supply chain stakeholders, firms can obtain greater performance of their overall supply chain e.g. higher profit margins, increased customer service level (Lee, 2000). The effectiveness of coordination is often dependent on several factors which vary from company to company.

Arshinder et al. (2008) display that there exists a necessity to implement a coordination system in order to surpass the challenges of the supply chain, as this is a dynamic structure that may evolve over time. As the value for the end-customer is created by following a channel among the supply chain, all the members should be involved and coordinate their operations with each other (Arshinder et al., 2008). To do so, different elements should be considered to bring and connect all the different functions together. These are: defining explicitly the processes, the responsibilities of each member and make the structure in line with the supply chain’s objectives.

4.1.2 Supply chain coordination framework

Ballou et al. (2000) have introduced a conceptual framework by considering the different levels of coordination among the organizations and functions involved in the supply chain. Thus, the supply chain management is viewed as the central concept
where three dimensions of coordination exists which are: *intra-functional, inter-functional, and inter-organizational coordination* (Figure 9).

The intra-functional coordination emphasizes on the activities and processes that take place only within the logistics function whereas the inter-functional coordination focuses on how the functions interact and are integrated with each other e.g. between the logistics and the manufacturing functions (Ballou, et al., 2000). The authors state that the supply chain management has evolved from an intra-functional view to an inter-functional or inter-organizational one. An inter-organizational coordination refers to the situation when the operations are carried out by different companies that are involved in the product-flow network e.g. a company and its suppliers (Ballou, et al., 2000).

![Figure 9. The supply chain coordination’s framework (inspired from Ballou, et al., 2000)](image)

4.1.3 Mechanisms towards supply chain coordination

In order to deal with the dependencies within the supply chain’s functions, members and organizations, there exist four different mechanisms (Arshinder et al. 2008). These are: supply chain contracts, information technology, information sharing and joint decision-making.
Supply chain contracts

According to Arshinder et al. (2008), while operating with different suppliers and buyers, firms can improve the relationship and have a better risk management by establishing supply chain contracts with the supply chain’s members. By doing so, this clarifies the relevant criteria such as quantities, price, delivery time, etc. Such method aims to enhance the supply chain’s profits, minimize the overstock as well as understock costs and spread the risks between the supply chain actors (Tsay, 1999). It has been shown that three different kinds of contracts exists, which are buyback, revenue sharing and quantity flexibility contracts (Arshinder et al., 2008).

Information technology

The information technology mechanism is generally used to enhance the coordination among firms involved in the product-flow channel (Sanders, 2008). This mechanism aims to create a linkage between the manufacturing and the delivery points. By focusing on real-time information, it enables firms to plan, track and evaluate the lead times. Different advanced information technology systems are commonly used such as the electronic data interchange (EDI) and the enterprise resource planning (ERP). These are tools that improve the communication regarding the shared data and products therefore it leads to a better efficiency of supply chain operations (Arshinder et al., 2008).

Information sharing

This mechanism refers to firms that are sharing the relevant data among the supply chain stakeholders regarding e.g. demand, inventory and orders (Arshinder et al., 2008). The potential outcome of an information sharing process between two companies is visibility, which leads to more effective supply chain (Jonsson & Mattsson, 2013).

By using this technique, companies increase the supplier service level as the suppliers get a better view about the key information required to organize their operations (Chen, et al., 2000). Jonsson and Mattsson (2013) discuss information sharing in a way to improve the management of material flows which they refer to as planning information. Further on, the authors divide planning information into either demand-related or supply-related. Demand-related planning information refers to data shared such as customer orders, Point-Of Sales (POS) data, forecasts, planned orders and available customer stock. Sharing these types of future oriented information facilitates the
planning of inventory management. Supply-related planning information rather refers to availability of supplier stock, lead times, deliveries expected to be delayed and shipping notices (Jonsson & Mattsson, 2013).

Joint decision-making

It remains of importance for firms to have coherence regarding the decision-making of the supply chain functions as this prevents and helps the problems resolution (Arshinder et al., 2008). Many perspectives are considered while performing coordination such as workforce, technology, firm’s strategic objectives, linkage among the supply chain members, sharing of competencies and benefits (Gittel & Weiss, 2004). The joint decision-making mechanism is used for different activities of the supply chain e.g. the replenishment (Ming-Jong & Chuang-Chun, 2004), collaborative planning (Aviv, 2001) and frequency of orders (Cárdenas-Barrón, 2007).

4.1.4 Advantages of the supply chain coordination

Having coordination among the different supply chain functions and activities helps at improving the overall supply chain performance (Arshinder et al., 2008). In contrast, lacking in coordinating generally leads to imprecise forecasts, low usage capacity, high inventory and low customer service level (Ramdas & Spekman, 2000). Therefore, when firms coordinate their supply chain, they have the ability to manage the overstock, minimize the lead times and deal with demand’s uncertainty, which consequently enables more flexibility and improves the customer service level (Fisher, et al., 1994).

4.1.5 Limitations of supply chain coordination

As the supply chain structure of firms is likely to evolve over time, having a coordinated and unified system becomes challenging (Arshinder et al., 2008). While dealing with the workforce and different members among product-flow channel, some of these stakeholders can be affected by the high costs of establishing inter-organizational system (Zhao & Wang, 2002). Thereby, firms should rather start by looking at the aspects under which such system can be favorable for their business (Arshinder, et al., 2008).

4.1.6 Managerial implications

Lambert and Cooper (2000) state that managers are generally lacking at integrating and coordinating the whole product-flow channel among the supply chain stakeholders. In
order to cope with such challenges, all the members involved within the supply chain should perform their work towards “a unified system and coordinate with each other” (Arshinder et al., 2008). According to the authors, one of the most challenging aspects regarding the supply chain coordination is to develop the system among the different companies involved in the product-flow channel.

4.2 Lean supply chain management

4.2.1 Origin and definition

Lean Supply Chain Management (LSCM), developed in the early 1990s, is the integrated concept of lean and supply chain management (Bruce, et al., 2004). The lean concept, which aims to eliminate waste, reduce non-value activities and increase value-adding activities, has been relevant for manufacturing companies under a long period of time. However, companies are nowadays more integrated with each other which create a waste-elimination need beyond the single company; hence the LSCM concept was developed (Liu, et al., 2013). Moreover Liu et al., (2013, pp. 2124) define the LSCM concept as “a supply chain operational and strategic philosophy that utilizes Internet-enabling technologies to effect the continuous regeneration of supplier and service partner networks”.

There is a clear need to reduce and eliminate different types of wastes at a specific location along the supply chain without interfering and increase the wastes occurring at other actors involved in the supply chain (Allesina, et al., 2010). To cope with this need, one should first have an understanding about the different types of wastes occurring in the supply chain. Further on, Wee and Wu (2009) suggest a VSM approach to identify the types of wastes occurring in the supply chain. Finally Liu et al., (2013) discuss the importance of a clear decision making in order to achieve a LSCM.

4.2.2 Waste

The concept of waste refers to the consumption of resources which does not add any value to the product (Pavnaskar, et al., 2003). According to Ohno (1988), the one who conceptualized Toyota Production System (TPS), waste can be divided into mainly seven categories for a manufacturing company. The types of wastes are: defects, inventory, motion of employees, over processing, overproduction, transportation and waiting periods. From a lean supply chain perspective, waste can be divided into either
micro-level or macro level whereas the micro-level refers to wastes occurring intra-organizational and the macro-level deals with inter-organizational waste. For instance, on micro-level the waste ‘overproduction’ refers to producing more than is needed by the next process in the operation whereas on macro-level it refers to producing more than needed by the downstream customers in the supply chain (Liu, et al., 2013).

Exposing and classifying waste in a company or a supply chain can be the initial step in improving the organization. However, the identification is useless if the waste cannot be eliminated or at least reduced (Pavnaskar, et al., 2003).

Cause-and-effect diagram are an often applied tool to track the root cause of the waste occurrence. The diagram is illustrating the relationship between causal factors and its outcome. The objective of improving the quality of the outcome must be approached by analyzing the causal factors (Ishikawa, 1990).

4.2.3 Value Stream Mapping

Value stream mapping (VSM) was conceptualized in 1999 (Rother & Shook, 1999) and origins from the waste elimination focusing concepts Lean management and TPS (Pavnaskar, et al., 2003). VSM is argued to be a systematical and graphical approach to reengineer the value stream in order to minimize waste (Schmidtke, et al., 2014). A value stream includes all the activities involved to bring a product from its raw material stage through production and to the final customer. These activities are divided into value adding actions, non-value adding actions and unavoidable non-value adding actions (Rother & Shook, 1999). The objective of performing a VSM is to identify and minimize the unavoidable non-value adding actions and eliminate the non-adding value actions referred to as Muda the Japanese word for waste (Lacerda, et al., 2016).

The VSM approach is a simple pencil and paper tool which enables to visualize the whole material and information flow through applying different symbols. These symbols are representing the different activities in the material flow including processes, movement, information flow and inventory. A data box is added underneath the symbols to illustrate the activity’s capacity and lead time (Rother & Shook, 1999). A list of the symbols along with an explanation of them can be found in the Appendix D.
Practical application

Performing a Value Stream Mapping basically includes four phases: Select a product family, Current-state drawing, Future-state drawing and Work plan (Rother & Shook, 1999).

![Diagram of VSM process]

Figure 10. The VSM process (own figure)

Select a product family is the first phase in performing a value stream mapping. The selection of a product family is relevant since it limits the scope and avoids over-complication of the project. The product family involves a group of products having the same or similar processing steps (Schmidtke, et al., 2014).

The second phase in the VSM process is the current-state drawing where the current production and material flow are identified, analyzed and visualized. The first step in the current-state phase is to take a walk and draw a rough sketch of the material flow to first get a brief understanding about the value stream and its different activities (Jones & Womack, 2002). When the researchers have a clear understanding about the value stream, the collection of data can start. The value stream data includes among others lead-times, capacity, storage time, transportation time and set-up times (Jones & Womack, 2002). The activities should also be divided into the three types of value stream activities explained in previous paragraph: value adding actions, non-value adding actions and unavoidable non-value adding actions (Jones & Womack, 2002). The final step in this phase is to include the information flow, divided into manual and electrical flow, which is also considered to be one of the most challenging parts since
managers between different functions in general have poor contact (Jones & Womack, 2002). The information flow is essential to analyze since it illustrates how each process knows what to make for its customer (the following process). Either the material flow involves a push or pull structure (Rother & Shook, 1999).

The next phase in the VSM process is to draw the future-state map which also is the main purpose of performing a VSM since it is displaying how the material flow shall be constructed in order to minimize waste and enhance the efficiency (Rother & Shook, 1999). The objective is to build a chain of interfacing processes that are linked to the customer either by continuous flow or pull structure which are producing exactly what a customer needs when he wants it (Rother & Shook, 1999).

The final step in the VSM is the work plan which implies the implementation of the drawn future-state map (Jones & Womack, 2002). The work plan includes a distinct description of what needs to be done, who needs to do it, a timeframe and measurable objectives (Rother & Shook, 1999).

**Limitations of VSM**

Even if there are several advantages by performing a VSM, the approach still have some limitations. Schmidtke et al. (2014, p.6149) list three different limitations of VSM:

- **Process variability** – VSM provides a rather static picture which may imply shortages if the production plant is subject to a heavy variability of processes and customer demand.
- **Complex process flow** – In many industries the material flow is more complex and non-linear since more actors are involved and reversed logistics has enhanced. There is therefore a risk that VSM is unable to cope with the complexity and that the implementation of the future-state map is time and cost-consuming.
- **Conflicting cost factors** – The future state guidelines supports flexibility approaches to produce the exact quantity at the right time to the customer. However this approach may conflict with other cost considerations. Therefore, in a classical VSM projects two questions often remain unanswered: If the proposed future state map is feasible and the map is beneficial when all cost factors are considered?
Moreover, the pure material pull approach of VSM may not be optimal in companies acting within high variety low volume industries (Bertolini, et al., 2013).

4.2.4 Decision making in LSCM
The key to a successful LSCM excluded of wastes is attaining a successful integration of the different functions existing in the supply chain and its members such that all activities are aligned to achieve an overall system objective (Manuj & Sahin, 2011). However, the complexity of the supply chains are continuously increasing, resulting in major challenges of managing it successfully (Liu, et al., 2013).

One of the key decision support requirements for LSCM is knowledge management (Guerra-Zubiaga & Young, 2008). Knowledge management involves efficient knowledge flows and knowledge sharing process among the supply chain actors which contributes to three main advantages along the supply chain: agility, adaptability and alignment (Liu, et al., 2013).

Liu, et al., (2013) developed a knowledge management framework to support the elimination of the seven types of wastes existing in the supply chain. The framework consists of four knowledge layers. The first layer is the Know-what, which refers to important information regarding problems or solutions of the supply chain wastes and shall be stored in a knowledge base. The second layer is the Know-how, which refers to how the waste shall be eliminated. Examples of the Know-how are strategies, models and rules. Further on, the third layer is the Know-why focuses on the source of the waste. Finally the last layer, Know-with, refers to the integration between the different partners in the supply chain. By defining the relational knowledge between the partners, addressing how to eliminate one type of waste without negatively affecting other types of waste in the supply chain will be easier (Liu, et al., 2013). Bellow the knowledge management framework is illustrated displaying the practical implication of the model.
The knowledge management framework is one of total five components in order to develop a lean knowledge system. The other components are: a supply chain decision network manager, a waste elimination knowledge base, an inference engine and a decision justifier (Liu, et al., 2013).

4.3 Total logistics cost

Considering that the logistics is characterized as a function operating in a dynamic and fast changing environment, this complicates the process of planning an efficient structure (Rushton, et al., 2014). According to Jonsson (2008), while costs are reduced for one logistics activity, it can create costs for other ones. Defining how changes in one logistic activity will influence the overall system remains difficult (Rushton et al., 2006). As it will help the understanding of the relationships among the activities, having a total picture of the costs while performing logistic activities and taking decisions becomes essential (Arnold, et al., 2008). The core purpose of the logistics function is to fulfill the service level expected by the customers to a minimum total cost. This means that rather than minimizing the costs for individual logistic activities, the system is considered as a whole where the costs should be reduced in their totality (Arnold, et al., 2008).
4.3.1 Costs involved in the logistics function

Obviously there are several types of costs involved in the holistically view of logistics costs. Jonsson (2008, pp. 101-102) has a broad view of the total logistics cost concept and breaks down the costs into the following types:

- Transportation and handling costs
- Packaging costs
- Inventory carrying costs
- Administrative costs
- Ordering costs
- Capacity-related costs
- Shortage and delay costs
- Environmental costs

However, this broad view of the total logistics cost concept is not shared with everyone (Santos, et al., 2016). Instead, Hevenga (2010) advocates that the logistics concept only shall be divided between transportation costs, storage and handling costs and administration costs. Due to limitations mentioned earlier in this study, this study will only analyze parts of these types of costs. Therefore, only the following are described more thoroughly:

![Figure 12. Relevant logistics costs for this study (inspired from Jonsson, 2008)](image)

*Inventory carrying costs*

The costs related to products in stock are classified as inventory carrying costs (Jonsson, 2008). These are then based on the products quantity in stock which means that if the inventory increases, there will be higher costs (Arnold, et al., 2008). The inventory carrying costs are divided into three kinds of costs.
Firstly, the capital costs represent the financial investment that is rather done for the inventory than for other purpose (Arnold, et al., 2008). Thus, returning the capital tied up in stocks will mean to acquire the equivalence of the inventory carrying costs (Jonsson, 2008). Secondly, the storage costs cover all the activities that need to be done for handling and storing the products. These can be related to the storage equipment, stores personnel as well as store administration (Jonsson, 2008). Finally, the uncertainty costs refer to all the risks of keeping the products in stock. Arnold et al. (2008) classify these risks in four sections: obsolescence, damage, pilferage and deterioration.

Transportation costs

According to Jonsson (2008), generally, the transportation costs are related to the movement of the products from a facility to another point. As the transportation can be internal or external, different costs occur. The internal transportation includes the picking and material handling activities as well as the internal movements of the goods (Jonsson, 2008). In contrast, the external transportation refers to activities that are carried out between a company’s facility and external actors (e.g. supplier or customer). These can be loading/unloading, receiving and moving of products (Jonsson, 2008). Such operations are carried out by internal staff or are outsourced to a 3PL. The author states that while performing the transportation operations, the products are considered as tied-up capital. Moreover, the transportation costs usually represent a small part of firms’ the total logistics costs besides for the ones that are selling high-value products.

Capacity-related cost

A Capacity-related cost is mainly a fixed type of cost and refers to the costs related to available plants, machines and personnel. Also annual depreciation and costs for maintenance are related to the capacity-related costs. Since it is primary a fixed type of cost, a higher degree of utilization will decrease the cost per produced item and also then decrease the capacity-related costs (Jonsson, 2008).

4.3.2 Total cost analysis

All the logistics activities that are performed in order to deliver a product to the customer involve consumption of resources and thus also cost. It is therefore an advantage to eliminate all activities that are not necessary for achieving a specific performance objective set by the company. Through analyzing the total logistics costs
within a supply chain, the company can avoid sub-optimizing and instead identify the least resource consumption option (Jonsson, 2008). One method enables the practical application of this approach, which is the total logistics cost analysis (Rushton et al., 2006). The overall costs of the function are taking into consideration rather than reducing the cost for particular logistics activities. This is represented as a graphical model that is carried out before taking logistics decisions as for every possibility the overall costs are calculated (Jonsson, 2008).

Moreover, Rushton et al. (2014) suggest performing a value/time analysis which displays the points in the process where cost is incurred and value is added to the product. The objective of performing the analysis is to highlight and subsequently eliminate costs in the logistics operation. Traditionally in the manufacturing industry, value is added when the product is passing the production operations and becoming a finished product. At the same time, displayed in the analysis, costs occurs through the passing of time, for instance when the product is stored in work-in-progress between different operations.

One important part of the total logistics cost analysis is the customer service analysis, which emphasizes the relationship between the company and customer. Through performing a customer service analysis and identifying which customer service level has to be achieved will be an essential part of the assessment of the total logistics cost analysis (Rushton, et al., 2014).

Rushton et al. (2014) advocates that there are several critical decisions regarding the data collection that has to be respected in order to analyze the total logistics cost which are the unit of measure, the product groups, the customer classification and the time period.
5 Empirical findings

The following chapter provides the empirical data that have been gathered from Micropower and Ecotec. The different functions within the facilities’ supply chain will be presented. This will include the operations that take place at each function as well as how the information and decisions are carried out along the supply chain. The sources regarding the data collected are not mentioned as the methodology chapter already emphasizes on the respondents and the two methods used (interviews and observations).

5.1 Production department at Micropower

5.1.1 Different operations

Micropower is manufacturing to order as the process starts when the customers places an order. They are expected to produce an order placed by Ecotec within three weeks. The planning of the production takes three days ahead, meaning that the production manager has this timeframe to organize the production. This refers to checking the components in stock as well as prioritizing the orders placed by other customers. In total, there are two assembly lines within the production area. Regarding the chargers produced for Ecotec, the manufacturing process takes place in only one of these assembly lines. However, different chargers for other customers are also produced in this assembly line. This latter is divided into 8 different stations from 0 to 7, illustrated in figure 13, ideally occupying one operative worker at each station. A detailed description of the operations carried out, the decision made and the information shared at each station is displayed below.

Station 0 to 2: Assembly of components

A conveyor system connects the different stations and enables a steady flow of the chargers. The stations 0-2 are dedicated to the assembly of components on the charger and general inspections are done at these stations to ensure the quality from previous stations. All the required components are picked from shelves where the manufactured components are stored after the manufacturing operations. Therefore, the time of assembly includes the time for picking the components from the shelves.

Station 3: In-depth quality checking

The third station is an in-depth quality checking where the operative examines if each component is correctly assembled and that no defectives have occurred in the assembly.
This is made through software testing, which detects electrical interruptions in the components.

*Station 4: Case adding*

At this stage, the charger is composed with the case, which will protect it against external forces.

*Station 5: Fusion for double pack chargers*

The station 5 only occurs when there are double pack chargers to assembly. At this step, two chargers are fused to one double pack chargers. Meaning that excluding this step, there is no significant difference in the assembly-process between the two types of chargers. The double pack charger only takes twice as much time at each station since it involves two “chargers”.

*Station 6: Software configurations*

Standard software configurations are done at this station in order to set up the software system and make the chargers operational.

*Station 7: Final case adding*

As a final stage, the last case is added to the charger to create the end product.

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**Figure 13. The assembly line of the chargers at Micropower (own figure)**
5.2 Outbound and logistical operations from Micropower to Ecotec

5.2.1 Packaging and storing operations

When the chargers have reached the final station at the assembly line, they are stacked on a pallet, waiting to be shipped to the packaging area. As soon as the pallet is full, with five single and three double packed chargers, this is shipped away automatically with an AGV system. Finally received at the packaging area, the chargers are re-stacked on a new pallet and the AGV-system brings back the empty pallet to the assembly line. To protect the chargers from outer circumstances, these are carefully packed with a carton protection. In total, eight double pack chargers and 16 single pack chargers are stacked and packed on one pallet before entering the storage area. Further on, the chargers are then stored on racks until the shipment. An overview of the different operations can be seen in figure 14. As the company has adapted a dispatch strategy, meaning they never manufacture more than 10 chargers per manufacturing orders so the time the chargers wait in the racks varies depending on variables such as order shipment date. To cope with the high order volumes and the short lead time required by Ecotec, Micropower has setup a safety stock for different chargers.

![Diagram of operations](image)

Figure 14. Disposition of the different operations at Micropower (own figure)
5.2.2 Shipping operations
Annika Magnusson, order manager at Micropower, is the one accountable for the shipping operation between Micropower and Ecotec. At Micropower side, she is the intermediary between the transportation company in Sweden and Ecotec. However, the US facility always gives the confirmation regarding the shipping conditions before any agreement is signed. The actual operation is carried out through a 3PL partner called APC Logistics. A shared Excel-document (Open order document) between Micropower and Ecotec is setup in order to facilitate the planning and shipment management. This Excel-document is displaying all the relevant information related to the orders set by Ecotec such as the article number, the order number, the quantity, the model and the part number. Additionally, there are different delivery-related information such as time scheduled (in terms of week), state of the shipment (in transit, etc.), type of shipment, booking shipment, estimated time of arrival and date of arrival. Annika is continuously updating the Excel-document with the current state of the order e.g working in progress (WIP), waiting to be shipped and shipped. As mentioned earlier, the actual shipment is carried out through a 3PL with whom Annika contacts when the order is ready to be shipped. Generally, the company tries to ship as many orders as possible of orders at the same time when it is possible in order to reduce the shipment costs.

The shipment can be carried out through two different methods, either by ocean freight or by airfreight. Obviously, time and costs differ significantly between the two options. The shipment by airfreight takes approximately 10 days but is at the same time more expensive than ocean freight, which takes approximately 25 days. An accurate trade-off is therefore required to do before choosing airfreight. Below, it can be seen a graph summarizing the percentage of chargers shipped by airfreight in comparison to ocean freight from August 2014 to May 2016.
Generally, Jim Keyser, General Manager at Ecotec, decides which orders are required to be sent by airfreight. The airfreight shipments depend mainly on high customer requirements regarding the short delivery times, the high volumes ordered and the forecasting shortages. The products supplied by Micropower arrive first at the harbor in New York where the 3PL called Focus solutions carries out the receiving. The logistics company then delivers by truck the orders to the facility in Troy (Ohio).

5.3 Warehousing operations at Ecotec

5.3.1 The facility characteristics
The facility is divided between offices and a warehouse, which represents 1115 m². Seven people are full-time working. This includes three employees within the production department where the chargers are customized and four people spread over different functions. There are a customer service/order entry responsible, an engineer and the general manager. In addition, there is also one sales person based in New York.

5.3.2 The total sales
Since the acquisition of the company in 2012, Ecotec has grown in terms of sales. The total sales represented 200 000 USD in 2012 whereas it has increased to 8 210 000 USD.
in 2015, as summarized in the graph below. The objective for 2016 is to continue growing by 21% the total sales to reach 10M USD.

![Total sales of Ecotec](image)

*Figure 16. Ecotec's total sales (own figure)*

5.3.3 The main operations

*Receiving and storing*

Usually, between 10 and 12 pallets are delivered weekly to Ecotec. This means that in average 162 to 192 single pack chargers are weekly delivered to Ecotec, except during the four weeks summer vacation shutdown at Micropower. The shipments delivered by airfreight are however usually limited to 1-3 pallets per shipment.

When the shipment arrives at the facility, an operative is in charge of unloading the truck. Then an operative proceeds to the labeling of the pallets. The procedure consists of putting a bar code on the received pallets in order to know the date of arrival at Ecotec and the type of products that have been delivered. The chargers are then stocked on shelves. By using the bar code system, all the chargers can be scanned upon removal to define how long time they have been removed from service and placed on charge.

*Customization*

When an order takes place, the operatives in the production puts away the chargers by following the FIFO-rule thus the company sells in priority the chargers that come in the earliest within the warehouse. A pushcart is used to move the chargers from the storage to the production area and 2-3 chargers can go through the production line. The three
operatives working in the production department carry out the customization operation. The requirements of the chargers’ characteristics may differ among customers regarding the different voltages, software configurations, cables and outer protection.

**Packaging and shipping**

After this operation, the chargers go to the test area in order to guarantee that every customized part is well assembled and the charger is working correctly. As a final stage, the packaging operation is carried out. The chargers are put in individual boxes and each box is labeled with the reference of the order, put on a pallet, stored in the marshaling area and then shipped to the customers.

![Figure 17. Main operations carried out at Ecotec (own figure)](image)

5.3.4 Planning management

The forecasting is carried out through several different methods. Firstly, they base their forecasting on historical sales. However, since they have grown in sales tremendously the last years, the historical sales data are not so reliable anymore. Therefore, they do their own estimations on what they will sell the next coming of months. Recently, they have established a type of material requirements planning system (MRP) called Fishbowl, which is also working as a forecasting tool. However since the Fishbowl system only has been established five months ago, the fully potential of it has not been yielded yet. Still the management at Ecotec has noticed an improvement in the forecasting due to the system.

The general manager considers that they store more than they need on a monthly basis. He outlines that it could be financially difficult to increase the inventory because the level is already considered high so is the capital tied up. Nevertheless from a logistical perspective, the company would be able to store more products.
5.3.5 Customer perspective

The different categories of customers

The company’s biggest type of customer in terms of turnover is the battery manufacturers. The two other types of customers are the forklifts manufacturers as well as the dealers that are selling the products to service companies. One of the most important customers for Ecotec is the battery manufacturer Customer 1 based in Fremont (Ohio). This company is a key account as the battery manufacturer shares its distributors with Ecotec. This means that all the distributors can buy Ecotec’s chargers.

The customer as a central aspect

Generally, Ecotec places the customers as a priority. Answering to every customer’s requirements is the aim of the company in order to increase the customer retention. When a customer requires the products in a very short time frame, Ecotec aims to deliver them on time even though it will decrease their profit margin. Therefore, flexibility is a key aspect in the company’s strategy. This is why Jim Keyser defines the customer service level of Ecotec as high even though he could not provide a precise number/percentage.

The company charges their customers from X to XX USD per charger depending on the variances. According to Jim Keyser, the fluctuation in demand regarding the different variances is fairly constant. Nevertheless, four/five of these variances are sold every day. According to the General Manager, the most popular charger is the single pack charger. The most common voltage for the chargers sold on the North American market is the 10kW.
6 Analysis

The following chapter is structured according to the three research questions and will end with the main research question. Therefore, the first part will be dedicated to the VSM and its analysis. Then out of this map, the wastes can be identified and the sources determined in the second research question. In addition, these wastes will be transferred into costs to then determine which ones are relevant to focus on. In the third research question, the researchers provide solutions and inputs in order to minimize the main wastes and improve the supply chain coordination. In the main research question, a future state map will be drawn to help the visualization of the different actions and general learnings will be presented. The linkages between the theory and the empirical findings regarding each research question are displayed with the framework below.

![Diagram](image)

Figure 18. The analysis conceptual framework (own figure)
6.1 Research question 1

- What kinds of activities take place within the supply chain of Micropower and Ecotec and how are they coordinated?

The first research question aims to identify the different activities along the supply chain at Micropower and Ecotec and how they are coordinated. The LSCM tool VSM has been used to answer this research question. Therefore the chapter has been structured in alignment with the VSM application with first identifying the product family, thereafter present the current state map and finally analyze the current state map.

6.1.1 Product family

Micropower is supplying Ecotec with two kinds of chargers. These are characterized by two different sizes, Single pack charger and Double pack charger. In practical terms, the double pack charger need less time to charge a battery. From these two types of chargers it exists in total 26 variances that differ by their components as well as the different voltages (8kW, 10kW, 16kW, 20kW). The different voltages of the charger are suitable to different sizes of batteries. Further on, the chargers are customized at Ecotec in terms of cables’ length and software configurations regarding charging cycles (Gustafsson, 2016). The 26 variances are divided into sales volume since August 2014 and are presented in the two graphs below.

![Figure 19a. The most popular single pack chargers in terms of sales volume (Micropower, 2016)](image-url)
6.1.2 Current state map

The second step in a VSM is the current state map, which implies an identification and visualization of the different activities taking place in the supply chain. Regular VSM process is isolated to only cover a single company or a department (Rother & Shook, 1999). However, since this study is covering a supply chain between two companies, an extended VSM is performed. Due to this, Jones and Womack’s (2002) guidelines of how to perform an extended VSM are followed. The symbols used in the presented current state map can be found in appendix D. Moreover, the numbers expressed in the map, if there is nothing else mentioned, are referring to minutes. The figures over the timeline illustrates the time for the single pack chargers while the time beneath mirrors the double pack charger. This means that the total throughput time for a single pack charger is estimated to be 25 days and 128 minutes or 40 days and 128 minutes depending on which shipping method is used. For the double pack charger the total throughput time is instead 25/40 days and 179 minutes. However, it is important to mention that some of these figures are estimations made by the researchers. Clocking the processes at Ecotec in USA was obviously impossible in the limited timeframe the researchers had. The estimations made by the researchers are reviewed by shop-floor workers and the management in order to ensure the validity.
6.1.3 Analysis of the current state map

Analysis of the activities

The assembly starts when the shop-floor workers receive a manual order defining the quantity and type of variance they will produce. The worker occupying the first station in the assembly line then goes to different shelves to gather the required components. The components inventory is organized through a lean supermarket set-up which means that the customer (the employee) just draw components from the shelves and then the department accountable for the component manufacturing is responsible for the replenishment of the components on the shelves (Rother & Shook, 1999). According to unstructured interviews with shop-floor workers, this is a time-consuming task since they have to manually count each batch of components and also, sometimes when the components are missing from the shelves the workers have to write an internal order and then wait until it gets manufactured before they can start with the assembly. Sometimes they have to wait as long as 30 minutes until they can start with the assembly.

Through observations at the assembly line, the researchers also discovered that a buffer of chargers occurs from various reasons. The buffer on the assembly line is impacting
the chargers throughput time, which in a longer perspective also has impact on the production capacity and the lead time (Jones & Womack, 2002). Through clocking the assembly line, the ideal capacity is shown to be 40 SP chargers and 20 DP chargers per day. However, the buffer is identified to limit this capacity to only 38 SP chargers per day.

Moreover, when the chargers are finished in the assembly line those are transported to the storage area where the packaging process takes place. The operation starts at the packaging process at Micropower. 16 single pack chargers and 8 double pack chargers fit in each pallet. When the chargers are packed, they are stored in a WIP inventory to wait to the remaining chargers are manufactured. According to Mattisson (2016) the time at the WIP inventory may differ depending on incoming orders from other customers.

A safety-stock is also established for six types of chargers shipped to Ecotec. Mattisson (2016) argues that this was established in order to cope with short lead time requirements. Since the establishment of the safety stock the management has seen a decreased need to use the costly airfreight shipment method to keep the delivery (Mattisson, 2016). However, the safety-stock ties up important capital and warehouse space, which could be used for other investments (Jonsson, 2008). In the table below the volume of chargers and the value (based on a fixed average sales price and a conversion rate of USD 1 = 8 SEK) of the safety stock is presented.

<table>
<thead>
<tr>
<th>Type of Charger</th>
<th>Volume of safety</th>
<th>Value of safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charger 1</td>
<td>X</td>
<td>XX XXX SEK</td>
</tr>
<tr>
<td>Charger 2</td>
<td>X</td>
<td>XXX XXX SEK</td>
</tr>
<tr>
<td>Charger 3</td>
<td>X</td>
<td>XXX XXX SEK</td>
</tr>
<tr>
<td>Charger 4</td>
<td>X</td>
<td>XX XXX SEK</td>
</tr>
<tr>
<td>Charger 5</td>
<td>X</td>
<td>XXX XXX SEK</td>
</tr>
</tbody>
</table>

Table 3. The safety stock at Micropower and its value
Furthermore, the shipping operation, which are carried out through either airfreight or ocean freight, is a challenging trade-off for the companies. Obviously the airfreight is less time consuming but also more expensive. According to the General Manager at Ecotec Jim Keyser (2016) the airfreight costs for an average pallet of chargers cost $1050 while it only cost $350 with ocean freight. Obviously the objective is to ship all the chargers through ocean freight in order to save costs (Gustafsson, 2016). However, the airfreight has advantages as well, despite the high expenses – such as less capital-tied up (Jonsson, 2008) and the possibility of a shorter total through put time (Rother & Shook, 1999).

Deliveries from Micropower arrive every week to Ecotec and have increased the last months. The first activity that takes place at Ecotec is the receiving and storage activity, which also include labeling and unpacking. Secondly, the main activity at Ecotec is the customization activity. The General Manager, Jim Keyser (2016) states that they have an average capacity of produce 25 chargers per day. Divided by three employees at the shop floor and eight hours per day this implies that it takes approximately one hour per charger. He also states that they have seen an increased demand the last decades, which have forced them to look for more employees. Figure 16 in the previous chapter is illustrating the tremendously increased demand the last years.

Analysis of the coordination of the activities

The second part of the research question refers to how the activities are coordinated. To analyze the coordination of the activities Ballou et al. (2000) framework of supply chain coordination is used. The first activity at Micropower, picking of components, is inter-functional coordinated and are connected to the second activity – the assembly of the chargers. Moreover, this activity is also coordinated through an inter-functional but also an inter-organizational type (Ballou, et al., 2000). The inter-functional coordination is facilitated through a system (MRP), which is connecting the activities related to the assembly. The inter-organizational coordination is carried out through the open order document that is set-up between the two facilities. Throughout this document, Ecotec can follow the status of the orders placed and also see when they are supposed to be shipped (Magnusson, 2016). This document can therefore also be referred to as mechanism of information sharing towards a well-coordinated supply chain (Arshinder, et al., 2008).
Furthermore, the type of shipping arrangement is also coordinated in an inter-organizational way since three actors are involved: Micropower, 3PL and Ecotec. Regarding the activities that take place at Ecotec, these are only intra or inter-functional coordinated (Keyser, 2016). This implies that Micropower has no visibility on those activities at Ecotec side. According to the Production Manager at Micropower, Mattisson (2016) this complicates the production planning for Micropower. The types of information requested are for instance the sales orders of Ecotec’s customers as well as the stock level at Ecotec. The production manager also states that he only sees the orders of Ecotec, which may differ tremendously in terms of volumes. The lack of visibility occurs mainly due to the usage of two different business systems, which cannot be integrated (Mattisson, 2016). This implies a shortage in the supply chain coordination mechanism: information sharing technology (Sanders, 2008). Other mechanisms towards coordination are supply chain contracts and a joint decision-making (Arshinder, et al., 2008). However, contracts are maybe not required due to the owner structure in the supply chain (Gustafsson, 2016).

<table>
<thead>
<tr>
<th>Type of activity</th>
<th>Area of responsibility</th>
<th>Type of coordination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picking of components</td>
<td>Micropower</td>
<td>Intra-functional Coordination</td>
</tr>
<tr>
<td>Assembly of the chargers</td>
<td>Micropower</td>
<td>Inter-functional/inter-organizational Coordination</td>
</tr>
<tr>
<td>Packing and storing</td>
<td>Micropower</td>
<td>Inter-functional/inter-organizational Coordination</td>
</tr>
<tr>
<td>Shipping</td>
<td>3PL</td>
<td>Inter-organizational Coordination</td>
</tr>
<tr>
<td>Receiving and storing</td>
<td>Ecotec</td>
<td>Intra-functional Coordination</td>
</tr>
<tr>
<td>Customization</td>
<td>Ecotec</td>
<td>Inter-functional Coordination</td>
</tr>
<tr>
<td>Packaging and Shipping</td>
<td>Ecotec</td>
<td>Inter-functional Coordination</td>
</tr>
</tbody>
</table>

Table 4. Types of coordination regarding the different activities

6.2 Research question 2

- What kinds of wastes can be identified and why do they occur?

The second research question aims to identify which types of wastes occur in the supply
chain and analyze why they occur. Through dissecting the current state map analysis in the previous chapter, six types of wastes can be identified in the supply chain within Micropower and Ecotec.

6.2.1 Identification of wastes and analysis of the sources

In order to identify wastes and the causal factors, a cause-and-effect diagram has been drawn. Thereby, the main functions within the supply chain of Micropower and Ecotec, starting at the upstream level, can be seen in the blue boxes while the wastes are written in blue text. These wastes are then spread over one or many sources written in black and represented by sub-arrows. All the arrows are linked to the main one leading to the wastes within the supply chain of Micropower and Ecotec. For a better reading flow, every area has been separately analyzed.

By looking at the first area, which is the production, the picking of components is an activity that required composing the chargers in the assembly line. There, two kinds of waste can be identified. According to unstructured interviews with shop-floor workers is the picking a time-consuming activity since it involves going to several shelves and manually count the required amount of components. As the counting of components can be associated with the motion of employees according to Ohno (1988), this operation is therefore classified as a type of waste. According to the shop-floor workers, this mainly occurs due to a lack of standardized batches of components.

The second waste has been identified in the same activity and refers to the waiting time of components that occasionally occurs. The shop-floor workers are arguing that the numbers of components on the shelves do not match the final order, which force them to wait until a new batch of components is produced. This is estimated to result in a 30 minutes waiting time for the shop-floor workers at the assembly line. From a lean and waste perspective, this issue is referring to waiting time (Ohno, 1988). The production manager Mattsson (2016) also advocates that this issue results from difficulties in matching the upstream activities with the downstream ones.

The next waste identified is located at the assembly line where a buffer of chargers occurs. This is negatively affecting the throughput time (Rother & Shook, 1999) and can also be referred to a waiting time type of waste (Ohno, 1988). Through eliminating this buffer, Mattisson (2016) argues that the lead time of manufacturing one standard
order can be decreased and the production planning would be more flexible. Through unstructured interviews with the shop-floor workers, the source of this waste can be referred to as a lack of workers occupying the stations as well as the size of the conveyor.

![Diagram of production wastes]

Figure 21. Wastes within the production (own figure)

The fourth type of waste identified is related to the safety stock at Micropower which currently ties-up capital for the firm. This is directly mirroring the inventory waste Ohno (1988) is referring to. The source of this waste can be traced to high fluctuations in demand from Ecotec. Ecotec is ordering high volumes with short lead times which are hampered through the lack of information sharing from Ecotec’s part. To cope with these factors, the production department at Micropower has established a safety stock so they can respond to Ecotec (Mattisson, 2016).
Next type of waste that occurs in the supply chain is the airfreight shipment that is accountable for a large part of the total shipping cost (Micropower, 2016). This is also directly mirroring the transportation waste in a lean perspective (Ohno, 1988). The waste occurs due to forecasting issues at Ecotec. The sales have grown tremendously the last years resulting the predictions made based on historical data are not reliable anymore (Keyser, 2016). Another source of the waste is the inventory management at Ecotec; obviously the management of the inventory is not working properly due to the amount of airfreight shipments.
The last type of waste identified in the supply chain is the excessive inventory at Ecotec. The excessive inventory refers to chargers in stock which has decreased in demand (Keyser, 2016). The source of this type of waste can also be traced back to forecasting issues at Ecotec (Jonsson, 2008).

![Excessive inventory level](image)

**Figure 24. Wastes within the storage at Ecotec (own figure)**

In order to provide the full picture of the wastes identified and their sources, the cause-and-effect diagram including all the different areas is presented below.

![Cause-and-effect diagram](image)

**Figure 25. The cause-and-effect diagram (own figure)**
6.2.2 Classification of the wastes through a coordination perspective

The different wastes can also be classified according to their source through a supply chain coordination perspective. The first two wastes identified: components shortages and counting of components, can be classified into a lack of inter-functional coordination within the production department at Micropower (Ballou, et al., 2000). The lack of inter-functional coordination becomes obvious due to the challenges of matching upstream activities with downstream within the production department. Moreover the buffer in the assembly line can be referred to as a lack of intra-functional coordination due to the level of isolation the waste occur within. The buffer is mainly occurring due to the size of the conveyor and the number of employees occupying it. The last three wastes, safety stock at Micropower, airfreight shipments and excessive inventory at Ecotec, can be classified into a lack of inter-organizational coordination. These wastes occur due to a lack of two-way information flow between the facilities (Ballou, et al., 2000).

6.2.3 Translating the wastes into costs

The wastes are translated to the three types of costs highlighted in the Chapter 4.3; Inventory carrying costs, Transportation costs and Capacity related costs. Obviously the inventory and transportation wastes are applicable to translate into the opposite costs. Furthermore, the wastes which are of another nature such as waiting time and motion of people are translated into capacity related costs since it impacts the utilization capacity (Jonsson, 2008).

The inventory carrying cost is calculated by using the inventory rate (7%) given by Gustavsson (2016) and applying it to the capital tied up. The calculation of the safety stock at Micropower is therefore based on the volume of chargers and its average sales price converted into Swedish kronor ($1=8SEK) and multiplied by the inventory rate. Estimations have been made when it comes to the excessive inventory at Ecotec due to lack of accurate information.

At the same time, the capacity-related costs are obviously of another nature and therefore also more complex to calculate. The researchers have therefore used two different ways to calculate this. Wastes that have direct impact on the degree of utilization in the production, such as buffer in the assembly line, have been calculated
through identifying the ideal (waste-free) production capacity. The costs are therefore the extra chargers they would be able to produce if the waste did not exist. Moreover, waste that does not have a direct impact on the degree of utilization in the production, such as the counting of components is instead calculated throughout a wage-perspective. The costs are therefore the consumption of time the wastes imply with a cost per hour of 250 SEK. The different costs shown in the table below have been changed by using a factor in order to protect the sensitive data provided by the case company as outlined in the Chapter 3.8.

More accurate explanation of the calculations can be found in Appendix F.

<table>
<thead>
<tr>
<th>Waste identified</th>
<th>Type of waste</th>
<th>Classification of the wastes</th>
<th>Type of cost</th>
<th>Actual cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Counting components</td>
<td>Motion of employees</td>
<td>Inter-functional coordination</td>
<td>Capacity-related cost</td>
<td>1500 SEK</td>
</tr>
<tr>
<td>2. Components shortages</td>
<td>Waiting time</td>
<td>Inter-functional coordination</td>
<td>Capacity-related cost</td>
<td>111 240 SEK</td>
</tr>
<tr>
<td>3. Buffer in assembly line</td>
<td>Waiting time</td>
<td>Intra-functional coordination</td>
<td>Capacity-related cost</td>
<td>494 400 SEK</td>
</tr>
<tr>
<td>4. Safety stock at Micropower</td>
<td>Inventory</td>
<td>Inter-organizational coordination</td>
<td>Inventory carrying cost</td>
<td>129780 SEK</td>
</tr>
<tr>
<td>5. Airfreight</td>
<td>Transportation</td>
<td>Inter-organizational coordination</td>
<td>Transportation cost</td>
<td>151 200 SEK</td>
</tr>
<tr>
<td>6. Excessive inventory at Ecotec</td>
<td>Inventory</td>
<td>Inter-organizational coordination</td>
<td>Inventory carrying cost</td>
<td>12 600 SEK</td>
</tr>
</tbody>
</table>

**Table 5. Costs related to the different wastes**

To provide a better visualization the wastes identified, a new map has been created and outlines in red boxes exactly at which level in the supply chain those wastes occur. They have been divided into three costs groups accordingly to the type of costs.
As it would be time consuming and perhaps not relevant to examine every type of waste, only the three main ones that represent higher costs for the case company as well as having the most impact on the customer service level. The costs that have been previously calculated based on time measures and estimations due to a lack of data. These costs are then put in relation with the customer service level. This last variable has been chosen since it is a main concern for the case company in addition to the costs. The graph below helps to classify the wastes regarding these two variables and enables the researchers to know which wastes it will be relevant to focus on. The wastes are represented according to their numbers (see Table 5) and are divided into three cost groups shown by different colors.
With this graph, it becomes clear that some wastes create more costs for the case company and have a bigger impact on the customer service level. Starting with the buffer (3), which is the most costly waste for the case company, this creates medium impact on the customer service level. This is explained by the fact that the buffer increases the lead time in the assembly line and therefore the three-week time for producing the chargers is increased. At the end, this is impacting the delivery lead time as the chargers may leave the Swedish factory later than planned. Secondly, the airfreight (5) is considered to have higher impact on the customer service level as this directly affects the delivery lead time. Then the safety stock at Micropower (4) is the third most important waste in terms of costs and has a high impact on customer service level since it will enable Micropower to decrease the delivery lead time. Even though the excessive inventory level at Ecotec (6) is the fifth most relevant waste regarding the customer service level variable, this will not be further examined due to the low cost impact as well as the lack of data and the difficulties at clocking the processes at Ecotec. Regarding the two last wastes, the components shortages and the counting of components, they both represent the lowest costs for the case company. Moreover, they affect the customer service level to a lesser extent, as these will not be really significant regarding the lead time thus the researchers will not focus on these wastes.
6.3 Research question 3

- What should be done in order to minimize these wastes?

The third research question aims at identifying possible solutions and actions of how to minimize the different types of wastes. As outlined in the end of the chapter 6.2, this chapter will focus on how to minimize the wastes that has the most cost impact as well as the most impact on the service level – the buffer in the assembly line, the safety stock at Micropower and the airfreight cost.

6.3.1 Actions to eliminate buffer in the assembly line

All three types of wastes and the activities they occur within are not isolated functions but are instead integrated with each other and part of the whole supply chain. The challenge is therefore to find solutions of how to minimize on type of waste without negatively interfere in another type of waste (Allesina, et al., 2010). This is the objective of the LSCM concept (Bruce, et al., 2004) which guidelines therefore have been applied within this analysis.

The first type of waste identified is occurring in the assembly line and are negatively affecting the lead time. As outlined in previous chapter, an elimination of this type of waste would impact the production capacity but in a lesser extent. However, when calculating the ideal production capacity of the assembly line with the sales price, it becomes obvious that an elimination of the waste has significant positive impacts. It will for example influence the minimization of the other types of wastes such as the airfreight and the safety stock. So, how shall the buffer in the assembly line then be eliminated or minimized?

Referring back to the LSCM and the knowledge framework developed by Liu et al., (2013) the four know questions know-what, know-why, know-how and know-with will provide a structure in order to minimize a waste occurring in a supply chain. However, by answering to the identification of the wastes and the causal factors in the previous part (6.2), the first two questions are already outlined.

The buffer is a waiting time type of waste and occurs due to mainly three reasons; excessively long conveyor, lack of employees occupying the stations and bottlenecks at the stations (fixed stations). The know-how question can be answered with two simple
points. The conveyor size should be decreased and the workforce should be increased. This will enable to have the required number of operatives at each station of the assembly line rather than hiring extra workforce as the last months, a total of eight extra workers has already been required to keep up with the increased demand. These ideas are based on discussion with the production manager Mattisson (2016) as this was something that he already aimed to apply.

The *know-with* question of this approach will include the upstream activities carried out within Micropower. There has to be a better match between the activities producing components at Micropower and the assembly line. Unstructured interviews with shop-floor workers states that there occurs a gap between required demands from assembly line and actual produced by the upstream activities. This implies a shortage in the coordination mechanism *Information technology* (Arshinder, et al., 2008) since Micropower is using a MRP system to coordinate the upstream activities. This shortage can be mitigated through increasing the stock of components. The *know-with* answer is therefore a closer collaboration between the assembly line and upstream activities.

### 6.3.2 Actions to eliminate the safety stock at Micropower

Next type of waste identified is the safety stock, which ties up capital for Micropower. From a lean perspective, this is translated to an inventory type of waste (Rother & Shook, 1999). The reason for the occurrence is to cope with fluctuations in demand from Ecotec and a desire to minimize the airfreight shipments (Mattisson, 2016). Through analyzing the open order document set up between the companies it can be stated that the airfreight shipment actual has decreased since the establishment of the safety stock (Micropower, 2016). The challenge is therefore to minimize the safety stock without negatively affect the airfreight shipments. Allesina et al., (2010) discuss the challenge of improving one function without knowing how it will affect the next functions and states that a holistic trade-off between the supply chain actors is required.

Since the *know-why* of this waste is referring to a downstream issue regarding lead-time, the *know-how* to minimize the issue is related to the upstream information flow between the different functions. Currently, the production manager at Micropower, Mattisson states that he does not have any cooperation with Ecotec, which challenges the production planning (Mattisson, 2016). Ecotec is ordering quite high volumes with
relatively short delivery lead times and to cope with these requirements, Micropower has set up a safety stock. However, through having a perception of the future demand, the production planning can be more effective which would reduce the need for the safety stock. Integrated information sharing with the company regarding future sales at Ecotec would simplify the production planning for Mattisson at Micropower. Accordingly to Mattsson and Jonsson (2013) sharing demand-related information may imply advantages such as decreased lead-times and higher production utilizations. Therefore, possible actions may be to develop the open order document that is set up between the companies. Currently this document is only working unilateral from Micropower to Ecotec visualizing supply-related information. A development of this open order document would therefore imply Ecotec visualizing demand-related information, such as future demand, order stock and stock on hand, which would make the document bilateral rather than unilateral (Jonsson & Mattsson, 2013). Hence, the answer to the know-how and know-with questions are connected, there is a need for better information sharing regarding customer demand at Ecotec which would facilitate the production planning and eliminate the need for a safety stock.

6.3.3 Actions to minimize airfreight shipments between Micropower and Ecotec

Regarding the third kind of waste, the airfreight shipment, the know-what has been defined previously as a transportation type of waste. Then the know-why refers to the source of this waste, which is the lack of reliable information regarding the forecasting as well as poor inventory management at Ecotec. When coming to the know-how, this helps to determine how the wastes can be eliminated (Liu, et al., 2013).

The inventory should be managed in a way that only the most popular variances sold to Ecotec’s customers would be in the safety stock. These variances are based on the analysis of the open order document.

Having a higher safety stock regarding those variances will enable the company to be more flexible and reply faster to the customers’ orders as the variances ordered will be on stock. Consequently, this means that the airfreight shipment will be decreased, as the main variances will be available in the safety stock. Furthermore, a more integrated system, as discussed in previous chapter, could help Ecotec at decreasing the airfreight shipment. It will enable Micropower to have a visibility on the sales orders placed by
Ecotec’s customers as well as the stock level. Therefore, by having the access to this information, the production manager can better organize and plan the production process.

A lack of reliable information regarding the forecasting refers mainly to a lack of inter-organizational coordination according to Ballou et al. (2000). In order to cope with this issue, a better relationship among the whole channel should be established. Ecotec’s customers are mainly battery manufacturers meaning they are the channel out to the end customer for Ecotec. Having a better collaboration with the manufacturers would therefore imply a possibility to take part of their forecasting and hence improving the inventory management. Therefore, the know-with becomes obvious as having a better communication among the supply chain imply all the actors within the channel. There exists also a need for a better cooperation between Micropower and Ecotec regarding the information sharing.

To summarize the actions needed from the knowledge framework approach a table is presented below.
<table>
<thead>
<tr>
<th>Wastes identified</th>
<th>Know-what</th>
<th>Know-why</th>
<th>Know-how</th>
<th>Know-with</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer in assembly line</td>
<td>Waiting time</td>
<td>- Conveyor size</td>
<td>- Reduction of the conveyor’s size</td>
<td>- Need for cooperation between the production and the upstream level</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Lack of workforce to occupy the stations</td>
<td>- Increase of the workforce</td>
<td></td>
</tr>
<tr>
<td>Safety stock (at Ecotec)</td>
<td>Inventory</td>
<td>- Fluctuation in demand at Ecotec</td>
<td>- Bilateral information sharing through Open Coordination document</td>
<td>- Need for cooperation between Micropower and Ecotec</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Lack of information sharing with Ecotec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airfreight shipment</td>
<td>Transport</td>
<td>- Lack of reliable information regarding the forecasting</td>
<td>- More integrated system to share the information</td>
<td>- Need for cooperation among the supply chain’s actors including the end customer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Poor inventory management at Ecotec</td>
<td>- Better inventory management at Ecotec</td>
<td></td>
</tr>
</tbody>
</table>

Table 6. The knowledge matrix
6.4 The main research question

- *How should the supply chain within Micropower and Ecotec be coordinated in order to minimize costs and keep high customer service level?*

The main question summarizes all the sub-questions and strives to identify how Micropower and Ecotec shall coordinate the supply chain in order to minimize the costs without affecting the customer service level. However, this chapter also aims to fulfill the second purpose of this study – identifying general learnings that can be applied for future offshore setups by Micropower.

6.4.1 Future state map

According to the LSCM approach that has been applied for this thesis, a future state map is presented to visualize which actions shall be carried out and their impact. These are mentioned with numbers from 1 to 5. These will be used in the explanations to facilitate the visualization of the critical areas where the actions should take place.

![Figure 28. Future state map (own figure)](image-url)
1. Better collaboration between upstream and downstream activities within the production department.

The first action refers to the inter-functional coordination between upstream and downstream activities within the production department. There is a need of cooperating between them in order to mitigate the component shortages for the assembly line. By having for instance an increased volume of components, this will support the assembly activity as there will be less shortages of components and the assembly line will not be interrupted which affect positively the lead time.

2. Reducing conveyor size and increase workforce at assembly line

The second action is referring to the conveyor line which should be reduced and occupied with more employees in order to achieve the ideal production capacity. These actions will eliminate the buffer and decreasing the lead-time and increasing the production capacity with two extra chargers (SP) per day.

3. Establishment of an Open coordination document

The third action is referring to the establishment of a bilateral information sharing document set up between the companies. This is an extended and developed version of the unilateral information sharing document already existing. The new Open coordination document will include information from Ecotec to Micropower regarding forecasts, order stock and stock level among others which will facilitate the production planning and decrease the need for a safety stock as well as airfreight shipments. This document can be referred to as information sharing, which is a supply chain coordination mechanism advocated by Ballou et al., (2000). The document is also in alignment with Jonsson and Mattsson’s (2013) theories regarding the importance of sharing both supply-related and demand-related information between companies in order to achieve efficient flows. The challenge of implementing this type of document is the time required to continuously updating it. The updating has to be made through people acting within several departments in the supply chain – Production Manager, Order Manager, and General Manager at Ecotec. This can be a time consuming assignment, which highlights the importance of justifying why it is needed – the cost savings.
4. More effective inventory management at Ecotec

The fourth action is refreeing to the inventory management at Ecotec which needs to be more effective. Chargers that are rarely sold should be phased out to make room for more popular variances. Throughout this strategy the stock of more popular chargers can be increased without increasing the total stock level.

5. Better cooperation with customers

The fifth type of action is referring to an increased collaboration between Ecotec and its big battery manufacturer customers. The manufacturers are Ecotec’s channel out to the end customer and through cooperating more with the wholesalers Ecotec can take part of their forecasting and therefore improve the inventory management as a result of this.

6.4.2 Cost savings through applying the actions

Through cost calculations within the supply chain, an elimination or minimization of these three types of waste would imply cost savings for both companies. Within the assembly line, a total of 40 extra chargers (SP) can be produced every month which in terms of sales accounts for approximately 450 000 SEK. Also the safety stock at Micropower can be eliminated through a more effective information sharing process – this accounts for a cost saving at approximately 123 000 SEK. The last waste, the airfreight shipment is difficult to minimize in order to stay flexible without keeping extremely high stock at Ecotec. However, the authors estimate that the airfreights can be minimized by 70% through more effective information sharing process and a more flexible production planning. This would imply a cost saving of total 105 840 SEK which represents only shipping 3 pallets instead of 12 pallets of chargers every month.

6.4.3 General learnings for the case company

Through this study, one can draw general learnings which can be used for future offshore subsidiary setups for Micropower. First of all, by examining the coordination within the supply chain of Micropower and its US subsidiary, it has become obvious that there should be a better cooperation and communication by sharing the information. This would enable a more efficient production planning at the parent company. Consequently the safety stock can be reduced to a minimum level and the delivery lead time can be shorter. This is why a particular attention should be given to the cooperation among the actors within the supply chain for instance by setting an open coordination
document as it is suggested for this case study. Regarding this document, it should include operational and tactical data regarding both supply-related information from the parent company and demand-related information from the subsidiary. This will increase the transparency between the different functions and hence enable more effective management of the supply chain. Moreover, there is also a need to outline the areas of responsibility to foster the communication between them and the executive decision making.

6.5 Theoretical reflection

From a more general perspective, similar types of wastes as the ones identified in previous chapter (inventory, waiting time & transportation wastes) can most probably be identified in almost every supply chain. The increased competition between supply chains has evolved in a need for identifying these wastes (Dwivedi & Butcher, 2009). As shown through this study, the LSCM approach is applicable to identify and classify the wastes along a supply chain and aims to provide solutions in order to eliminate those. However, this approach can be a time consuming and expensive process for companies to apply, especially if the supply chain involves different actors and several functions (Jones & Womack, 2002). Another challenging factor in the identification of waste is the lack of holistic measurement along the supply chain. A holistic measurement would enable companies to do accurate trade-offs along the supply chain and identify the ideal production planning, ideal stock level and so on (Jonsson & Mattsson, 2013). The lack of such trade-offs has been identified within this study when the case company seeks to balance the supply chain costs and the customer service level, which are two important and strategic variables for its business.

An effective supply chain coordination obviously mitigate the wastes through arising advantages such as decreased lead times, minimization of stock levels, increased flexibility and decreased manufacturing costs (Arshinder, et al., 2008). However, there are still major challenges of how to achieve effectively coordinate the supply chain and the consensus of what a well-coordinated supply chain actually implies. There exist challenges when it comes to managing the inter-dependencies between companies within the same supply chain. Every company has individual objective rather than the efficiency of the whole supply chain. This can also be hampered through possible cultural differences between actors within the same supply chain. In order to achieve an
effective supply chain, the information sharing between the actors is highly relevant (Jonsson & Mattsson, 2013). Such challenges are faced through coordination mechanisms such as information sharing, information technology, contracts and joint-decision making developed by Arshinder et al., (2008). The information-focused mechanisms enable a holistic visibility of the supply chain, which may create effective inventory management and less capital tied-up (Jonsson & Mattsson, 2013). However, companies rarely have a fully integrated system resulting in a need for the more time consuming activity information-sharing. This is the case for Micropower and Ecotec, whereas the information sharing is manually updated by the management at Micropower. The degree of time consumption combined with the not so explicit rewards from focusing on the coordination may negatively affect companies’ willingness of focusing on improving the supply chain coordination.

Moreover, another important aspect to consider within the coordination perspective is the areas of responsibilities. This area is not so examined or highlighted within the supply chain coordination theory. However, since the supply chain involves several functions in different companies there may be a lack of responsibility area regarding the effectiveness of the supply chain. This issue is thereby also connected to the lack of a holistic measurement within a supply chain.
7 Conclusion

In the following chapter the main research question is answered in order to fulfill the purpose of this thesis. The chapter also includes reflections of the study and suggestions of further research. Finally, the last part of the chapter involves a critical review of the study.

7.1 Answer to the main research question

How should the supply chain within Micropower and Ecotec be coordinated in order to minimize the costs and keep a high customer service level?

Throughout the LSCM approach, it has been identified that the coordination of the supply chain within Micropower and Ecotec is lacking at various levels. Mainly the inter-organizational coordination between Micropower and Ecotec is not done to a sufficient extent. This is also the case for the inter-functional coordination of the activities within Micropower which is lacking. Thereby, the cooperation between the activities within Micropower needs to be better matched by synchronizing the upstream activities with the downstream ones. In order to achieve an effective flow and avoid gap in the production flow, coordination mechanisms such as information sharing or information technology should be used. The upstream level should support the downstream activities by, for instance, increasing the stock level of components, which will help to solve the shortages issue.

Furthermore, improvements can be made regarding the inter-organizational coordination of the two facilities. The information sharing between those is currently lacking, resulting in the need for a safety stock establishment at Micropower and frequent airfreight shipments. The coordination mechanism information sharing should be bilateral rather than currently unilateral. Micropower should continue sharing their supply-related information, such as production planning, inventory and chargers in transit. At the same time, Ecotec shall supply Micropower with demand-related information such as order-stock, inventory and forecasting. This is suggested by the authors to be carried out through a development of the currently Open order document set up between the facilities and to be called Open coordination document instead. At Ecotec side, the inventory management should be more effective by keeping in stock
only the most popular variances and the information regarding the forecasting should be shared by its main customers. This will enable Ecotec to look far enough regarding the demand and set more accurate forecasting. Consequently, the production planning at Micropower will be better managed as there will be more visibility on Ecotec’s forecasts, which will reduce the need for the airfreight shipments.

Finally, general learnings can be made for Micropower in order to facilitate future offshore subsidiary set-ups. Firstly, the four coordination mechanisms should be respected already in the beginning of the set-up. The coordination mechanisms mitigate the occurrence of wastes and costs. Secondly, the areas of responsibility shall be declared between the companies in order to achieve an effective coordination of the supply chain.

7.2 Further research

Further research regarding the same scope as this study may imply a deeper investigation of the operations happening at Ecotec. This information has been lacking of various reasons within this study and it has therefore implied that the main focus has been on Micropower and the operations happening there. Throughout a deeper examination of the operations happening at Ecotec most probably more wastes can be identified and insights of further coordination recommendations can be made.

From a more general perspective, further research within the same area may be to identify a holistic measurement which can be used to measure the effectiveness of a coordinated supply chain. Due to the fact that there are several functions and different types of cost involved within a supply chain, the consensus of what an effective coordinated supply chain actually is are lacking. This becomes relevant since companies therefore can track and see what they can save by having a focus on supply chain coordination.

7.3 Own reflections

When we first started this project, we were not fully aware of the degree of complexity a supply chain includes. We also thought that the main focus would be at the subsidiary Ecotec rather than at Micropower which turning out was not the result. The degree of complexity combined with the short time frame has been challenging variables during
the project. However, we both think it has been an interesting project to lead and we have both learned a lot by gathering relevant experience of how to manage interdependencies between companies.

We have received a valuable experience through combining our academic knowledge with practical work experience from the business world. We think this experience will help us in the future to better understand supply chains and its complexity. We also think that the supply chain coordination theme, which is the main field of this study, is becoming more relevant in the future as there exists an increased competition between supply chains and a need for collaborating beyond the company’s borders. We hope that the actions identified will be helpful at improving the coordination between Micropower and Ecotec. Obviously, it would be more interesting and the result may have been better if we would obtain deeper insights about Ecotec’s business.

7.4 Critical review

It remains important to mention that the result of this thesis has been affected by some variables. Starting with the short time frame of 10 weeks, this has been a critical issue along the project. Trade-offs between the time given and the size of scope have been done. Obviously, this has affected the end result of the thesis.

Furthermore, it is also relevant to mention that there was a lack of empirical data gathering at Ecotec’s side. The empirical gathering has been difficult from a numerous of reasons. First, there is the time zone difference as well as a geographical distance, which both have complicated interviewing our contact and observations at the facility. There has also been an obstacle with receiving requested quantitative data from the facility. This mainly depends on that it has been difficult to get in contact with the general manager and that the data requested are unstructured and difficult to present for him.

Finally, estimations regarding the quantitative calculations have been made by the authors. Even though the estimations have been reviewed by the case company’s employees, the accuracy cannot be fully validated.
8 Reference list


Gustafsson, T., 2016. *Vice President Micropower* [Interview] (14 March 2016).


Appendix A - Interview guide for the Vice President of Micropower

Interviewee: T. Gustafsson (Vice President of Micropower)

Date: 2016-03-13

Supply chain structure
Planning, ordering and manufacturing operations

- Can you describe the currently used forecasting tool?
  - Do you have other integrated systems between the companies? (e.g. common system used in every plant so the stock level can be monitored)

- Can you explain the ordering procedure used now both at Micropower and at Ecotec?

- How is the order processing organized (time, customization and so on)?
  - Between Micropower and Ecotec?
  - Ecotec and the final customers?

- Is Micropower manufacturing to order or manufacturing to stock?
  - Is there a high obsolescence risk in this industry?

Logistics operations

- Can you extensively describe the logistics operations between MicroPower, Ecotec and their final customers?
  - Frequency of shipments to Ecotec?
  - How much ocean/air freight is used (in %)?
  - Time for ocean freight
  - Delivery time to customer (time from placing an order to receiving product)?
  - How many different modules does the supply chain include?

- Can you describe the warehousing operations at Ecotec and how big is the warehouse?
  How many people are working there?

- Can you describe the inventory management at Ecotec?
  - Does the company have a safety stock? If so, how much does it represent?
  - Inventory carrying costs? (Capital cost, storage cost & uncertainty cost)
  - Does the company use Economic order quantity?
  - Does the company use software tool?
Customer perspective

- Ecotec has 3 types of customers, but how many customers are there in total? And which one is the biggest customer?

- Having a high service level, is it an important aspect/critical success factor for Micropower and Ecotec?

- Does a contractual agreement regarding the service level exist between Ecotec and its customers? (e.g. agreement on late delivery and so on)

Further Research

- Who do you think we can interview in order to receive further information?
Appendix B - Interview guide to Production Manager and Order Manager

Interviewees: Andreas Mattisson (Production Manager at Micropower) & Annika Magnusson (Order Manager at Micropower)

Date: 2016-04-13

Interview guide for the Production Manager

- Where would you say the supply chain starts? (Our scope)
- How many components are involved for the two battery chargers?
  - Which ones do you purchase and which ones do you manufacture?
  - Do you have a stock of components for these two products?
- How often do you manufacture the two battery chargers for Ecotec?
  - What are they called? What are their characteristics?
  - (How long time does it take to manufacture and assembly each charger?)
  - Is there a stock of chargers?
  - In which degree are they customized here in Växjö? Where does the customization take place?
  - How many variances of the modules are sent to Ecotec?
- Is it a large set-up time in the production when changing to other chargers?
  - (If you following behind schedule, is it possible for extra shift if required?)
- Can you explain the logistic set-up between the two facilities? (How long are the chargers stored before shipping and so on)
- Information flow and material flow
  - How does the information flow work? e.g. when does the production know what and when to produce?
  - Can you draw the material flow (SC) how you see it?

Interview guide for the Order Manager

- Can you explain your role within the supply chain between Ecotec and Micropower?
  - Connection to other departments?
  - Connection with Ecotec? (frequency)
  - Connection with end-customers of Ecotec?
- Can you explain the information flow of ordering (from Ecotec to Micropower)?
- Do you have a control on the stock level of Ecotec? Is it a key aspect regarding the ordering process? Who decide when to order more chargers to Ecotec?
- Can you explain the safety stock arrangement? Safety stock in both Micropower and Ecotec?
- Can you explain your involvement of the shipping procedure?
  - Cost ocean freight vs air freight?
  - How long time do you expect the shipment takes?
  - Does it include the final customers of Ecotec?
When you need to ship by airfreight, what is the reason? E.g. Has the safety stock at Ecotec run out and customers have already placed an order or is it just small and needs to be replenished?

Where does the problem regarding shipment costs occur from your point of view? Can you draw the Supply chain from your point of view?

Relevant historical data (frequency of the orders, etc) that you can provide us with?

Interview guide for the Production Manager

Date: 2016-04-19

- When you receive an order from Ecotec – you have approximately 5-6 weeks before you have to send it. With ocean freight, this implies that Ecotec puts an order approximately 10 weeks before they expect having the chargers.
- Was Ecotec able to see the order stock of certain chargers?
- Torbjörn mentioned that there is a shared excel (dropbox) document, which works as a simple forecasting tool. Can you explain this further?
- Can you provide us with the name of the chargers? And point out which ones have a safety stock.
- How big is the safety stock for the other chargers?
- When do you start replenish your safety stock when it’s empty?
  - How often do you need to use chargers from the safety stock to be able to fulfill an order?
- Do you think Micropower has the production capacity to cope with the increased demand from the U.S market? Because last time we were here the safety stock was empty and maybe your order stock is too full to fulfill it.
- 5 stations? – Where does the motor assembly take place in the assembly line?
- What do you bill Ecotec per battery charger?
- Maria Ström – purchasing manager, is she only managing the procurement of components (which are out of our scope) or is it relevant that we also meet with her?
Appendix C – Interview guide for the General Manager at Ecotec

Interviewee: Jim Keyser (General Manager at Ecotec)

Date: 2016-04-26

Inbound logistics

- What chargers do you mainly order from Micropower? As we understand, the supply chain mainly consists of 2 types of chargers (single and double pack) which are divided into 26 different variances – Is this correct?

- Can you explain the logistics operations that take place between Micropower and Ecotec and your involvement?
  - Which transit way do the goods take? Växjö-Hamburg-New York-Troy? Air/ocean
  - Do you have any part of the shipping or do the goods arrive to the facilities without any involvement from your side? (The information flow between the different 3PL).

- What are the average costs of shipping between the two facilities. Air vs Ocean. (Price/pallet)

- Do you have a perception of how long time the two shipping methods take?
- Does it occur that shipment lead-times take longer than expected? Or do they often take the same time?

- You decide what type of shipping method that will be used. What are the main reasons for choosing the airfreight? Ex. already received an customer order that need to be shipped in short timeframe. Or quickly replenish stock to prepare for other orders.

Warehousing operations

- How big is the warehouse? And how many people are working there?
- Can you describe the operations and their order of occurrence that take place in Ecotec? Ex receiving, labeling software configurations, etc.
- Do you have any perception of different lead-times in the different processes?
- Do you have a customization-to-order strategy?
  - Is it correct that you receive an order from the customer, you process this order, and then you customize it before sending it?
  - Would you say that you have short lead-times in your indoor processes?
  - What is the average lead-time from receiving a customer order to you ship it?

- Is it possible to increase the capacity if needed by adding extra shifts or bring in short-term employees?

- Is it correct that you have a ERP system and an added fishbowl system? Can you describe in which way these two systems facilitate the planning management?
Customer

- Are there chargers’ variances that are mainly ordered by the customers? Or the customers have always different preferences?
- How critical is it for you to be able to deliver products to the customer within a short time frame?
  - What is the average delivery lead-time you have?
  - Have you lost customer due to short delivery requirements that you are not able to fulfill?
  - Does the required delivery lead-time differ between different kinds of customer?
- What customer service level do you have? Do some customers required higher service level or have specific requirements regarding the service?
- Has the demand increased during the last year? If so, what were the impacts on Ecotec? How did you face this challenge?
- What do you charge the customer per charger?
- Is it a high fluctuation in demand?
  - If so, does this complicates the planning and inventory management?

Planning management

- Can you tell us about the inventory of the chargers? What kind of stock do you have?
  - Do you have a safety stock for the different variances? And for the components?
- Is it possible to expand your (safety) stock of certain variances if needed? From a logistical, space and financial perspective.
- When you replenish your stock, how do you calculate the reordering point?
  - Does the ERP-system help you with this?
- What do you base the inventory planning on? Forecasts?
- Can you describe on what figures the forecast are based on?
  - Would you say that the forecasting is reliable?
  - How well involved are Micropower in the forecasting process, so they can be prepared for orders from you?
- Would you say a more integrated IT-system between the facilities would mitigate the need for airfreight shipments?
- In your opinion, what needs to be improved in order to decrease the airfreight shipments?
Appendix D – Value Stream Mapping symbols
Appendix E – Interview guide for the Production Manager and Order Manager

Interviewees: Andreas Mattisson (Production Manager at Micropower) & Annika Magnusson (Order Manager at Micropower)

Date: 2016-05-16

Interview guide for the Production Manager

- Who is deciding the shipping date of the order? Ecotec when they place the order, or Micropower and the production management?
- If Ecotec decide - Do they decide it to be shipped three weeks after the initial order is sent as they know that you then can cope with it (historical experience)?
- When do you start producing the chargers when an order from Ecotec is received? (approximately)

- Do you think the production limit of 10 chargers/day has impact on the amount of airfreight shipments?
- If so, how challenging is it to always respect the production limit of 10 chargers for Ecotec to keep the promised shipment date?
- Does this production limit imply that you produce chargers (Q1-10) almost every day to Ecotec?
- What consequences would it be if you decided to stop with the production limit and produce all the chargers needed at one time?

- Last time we were here you told us about the production management system. Can you tell us about it more? Who decides the priority of the orders manufactured?
- How is this information carried out to the shop-floor workers?

- Last time we were here, some of the shop-floor managers told us that scarcities of components involved in the chargers occur periodically. Can you describe how manufacturing of components work? Who is deciding when and what new types of components shall be manufactured?
- Would it be possible to increase the components inventory in order to avoid these scarcities?
- Would it otherwise be possible to match the quantity of components with the end-order in order to have equal amount of components and chargers?

- In what way has the safety stock of some chargers helped you mitigate the airfreight shipments?
- Do you have any perception at all of the shipping arrangements?
- Do you think a decrease in throughput time and increase in production capacity (through more assembly lines) would be able to decrease the safety stock but still also decrease airfreight shipments?
Do you think having knowledge about the customer demand at Ecotec would help you in the production planning?
Have you been taken part in the simple excel forecasting tool setup between the companies?

How often do you share the information with Annika? To which degree is the production function coordinated with the order management?
How often do you share information regarding the production and production capacity with Jim Keyser?

Conveyor investments
- An employee told us that you want to reduce the conveyor size in order to decrease the throughput time in the assembly line and avoid buffers.
- A decrease of the conveyor would of course lead to more space, would it be possible to use this space to add another assembly line and therefore increase the production capacity?

Interview guide for the Order Manager
- How does the forecasting tool (simple one) work and how often do you use it? To which extent do you use it?
- How often do you update the tool (I think you told us last time that you don’t have time to update it so often)?
- What is the main objective with establishing the tool?
- Depending on the objective, would it be helpful if this is updated more often?

How often do you receive orders from Ecotec? And how often do you ship to them (e.g every week? Once every two week)?

Do you have any outlined responsible to decrease the airfreight shipments?
How often do you share the information with Andreas?
Can you tell us about your information sharing with Jim? Is it just through the e-mails order and the planning document? Or do you also discuss the demand for Ecotec?
Does Jim know the safety stock level at Micropower? And do you think it would decrease the airfreight shipments if he knew?

Who is deciding the shipping date (when the orders will leave the facility in Sweden)?
In your opinion, would it facilitate if the demand at Ecotec would be more visible for you at Micropower?
Appendix F – Costs calculations

Counting of components.

Formula: Daily counting time*working days/month*hourly wage of 1 employee= Cost of manually count the components

Components shortages

Formula: Number of chargers that may be produced in one waiting time* Number of waiting times/months*average sales price in SEK= Cost of components shortages

Buffer in the assembly line

Formula: (Ideal produced chargers – actual produced chargers) * number of working days * average sales price = Cost of buffer in assembly line

Airfreight

Formula: Number of pallets shipped by airfreight*Cost per pallet in SEK= Cost of airfreight shipments/month

Excessive inventory at Ecotec

Formula: Volume of excessive inventory*Average sales price in SEK*inventory rate= Monthly cost of Excessive inventory

Safety stock at Micropower

Formula: Volume of safety stock* Internal sales price*inventory rate= Yearly cost of safety stock